



**SANFORD
UNDERGROUND
RESEARCH
FACILITY**

Opportunities at the Sanford Underground Research Facility

Jaret Heise, Science Director
jaret@sanfordlab.org

Quantum Partnership Workshop (UG Tour)
July 21, 2026

Sanford Underground Research Facility



SURF Mission:

We advance world-class science and inspire learning across generations.

SURF Vision:

The world's preferred location for underground science and education.

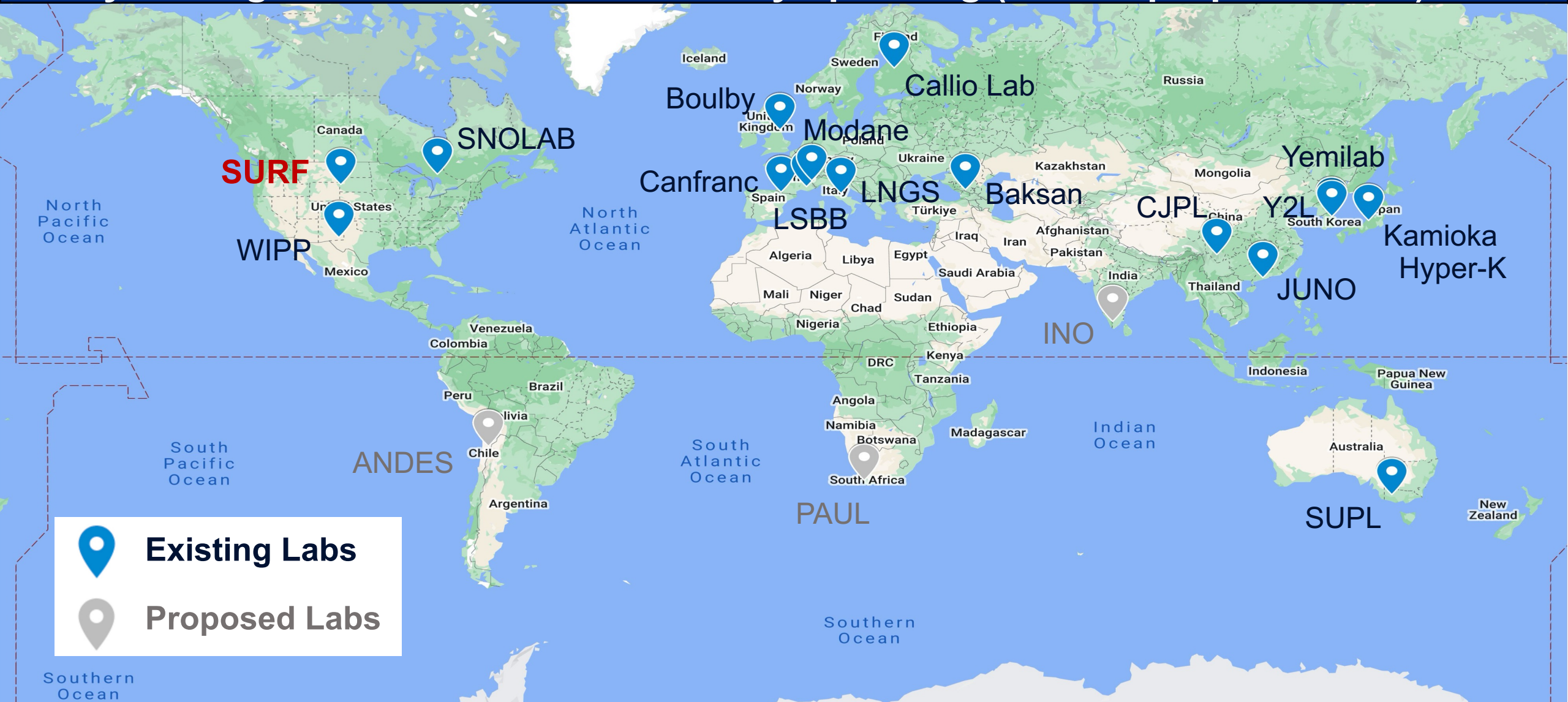
SURF serves the entire underground science community

SURF welcomes and encourages research from all disciplines that are able to take advantage of the unique attributes of our laboratory



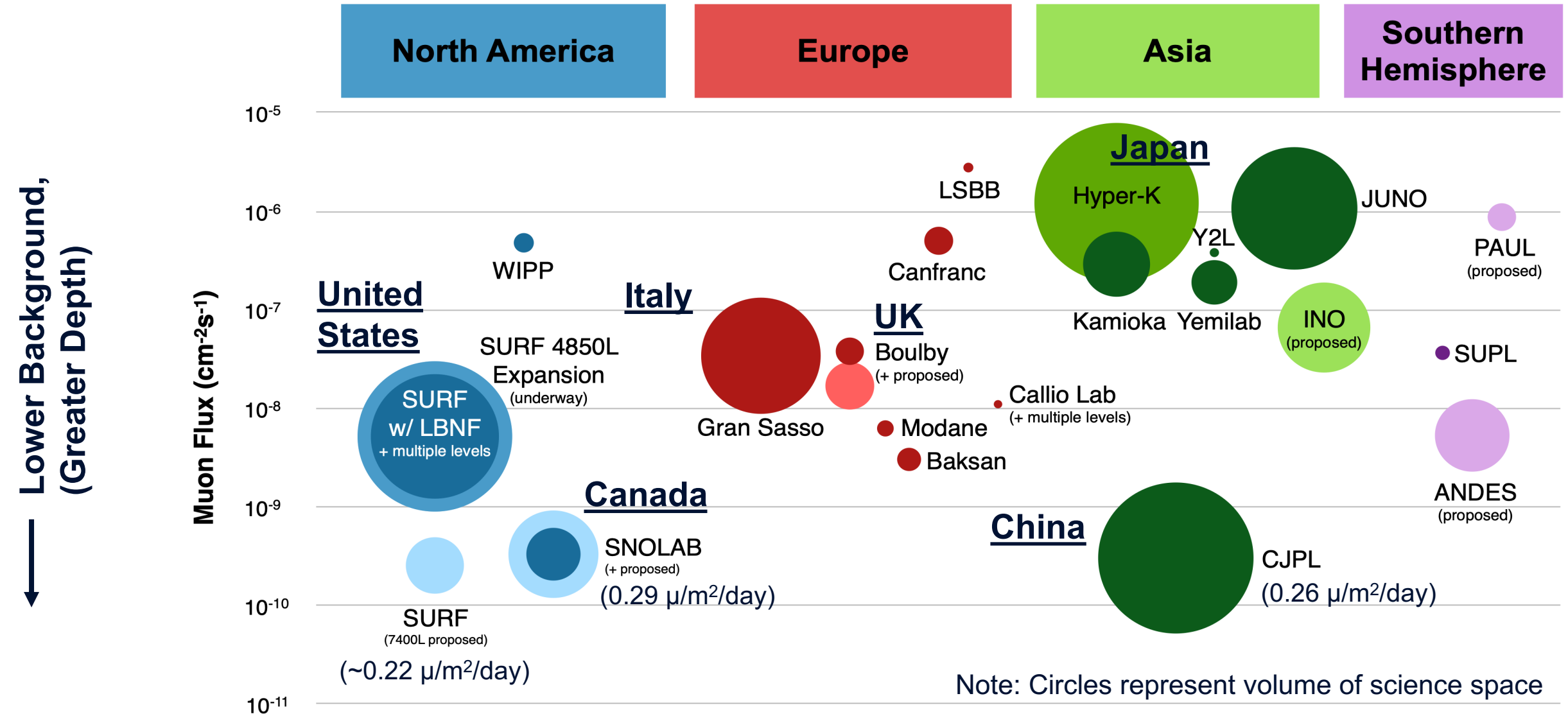
Where in the World is SURF?

Many underground laboratories currently operating (+ more proposed labs)



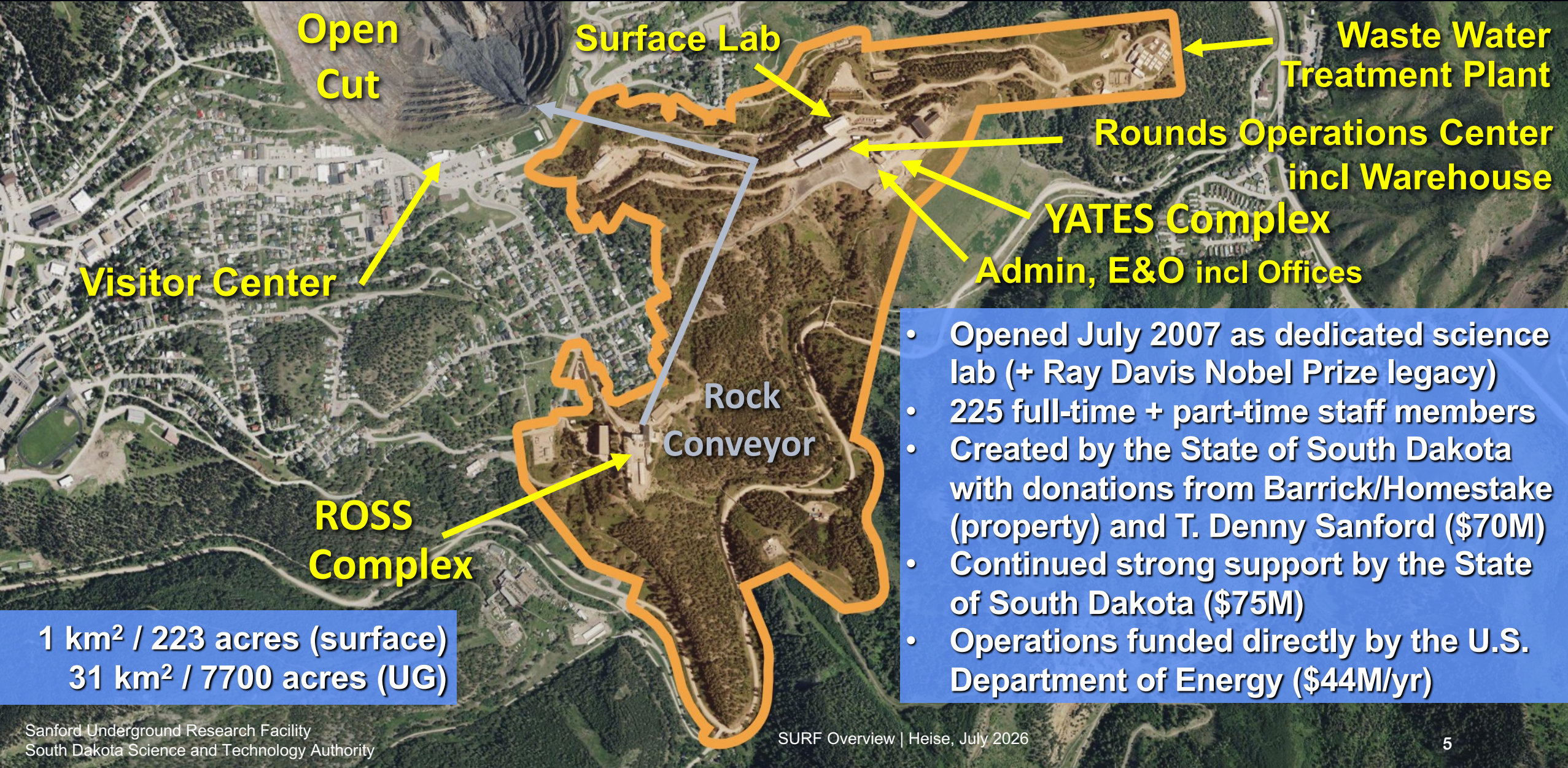
SURF in the Global Context

Deep site ($4.5 \mu\text{m}^2/\text{day}$) with significant expansion potential, max depth 2450 m



Sanford Underground Research Facility

Nation's deepest underground lab, advancing multi-disciplinary research

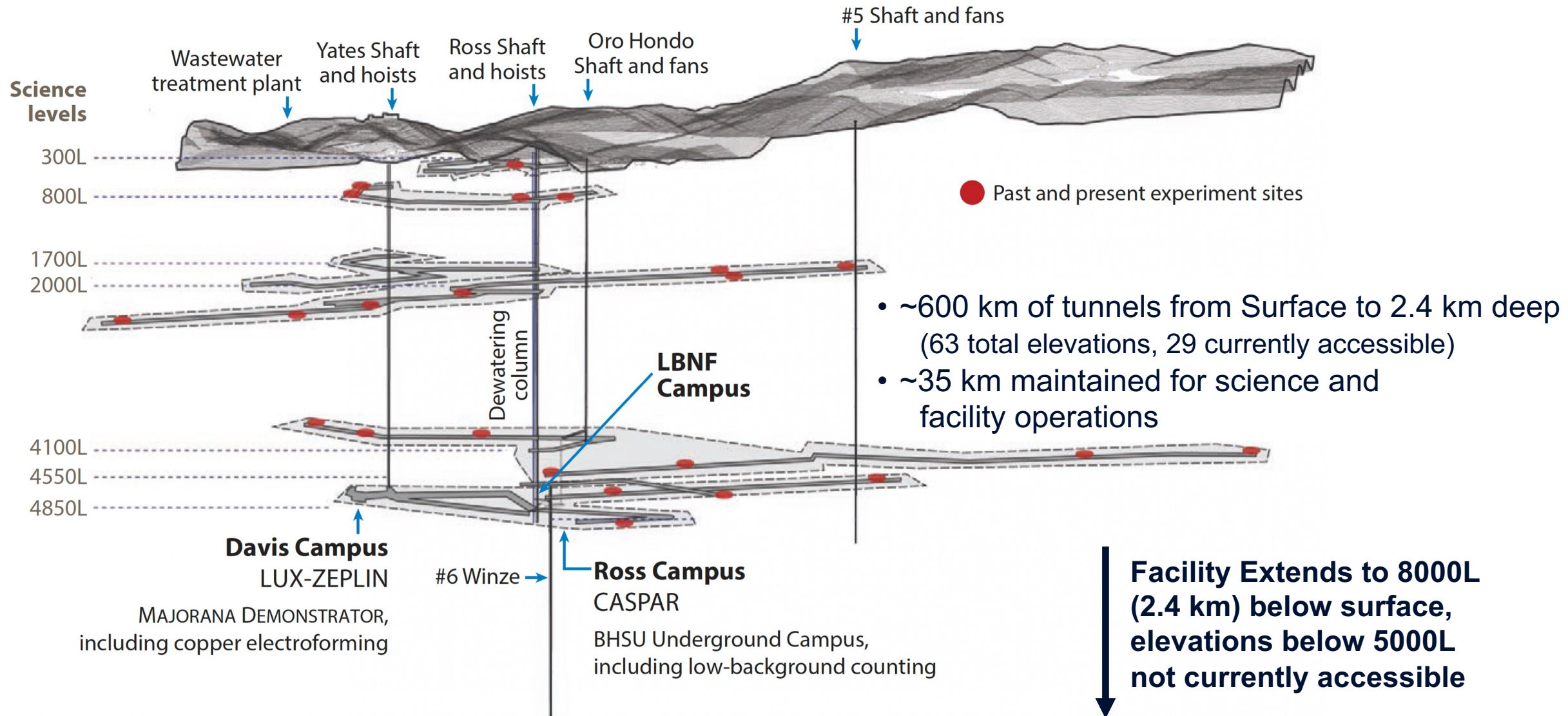


- Opened July 2007 as dedicated science lab (+ Ray Davis Nobel Prize legacy)
- 225 full-time + part-time staff members
- Created by the State of South Dakota with donations from Barrick/Homestake (property) and T. Denny Sanford (\$70M)
- Continued strong support by the State of South Dakota (\$75M)
- Operations funded directly by the U.S. Department of Energy (\$44M/yr)

1 km² / 223 acres (surface)
31 km² / 7700 acres (UG)

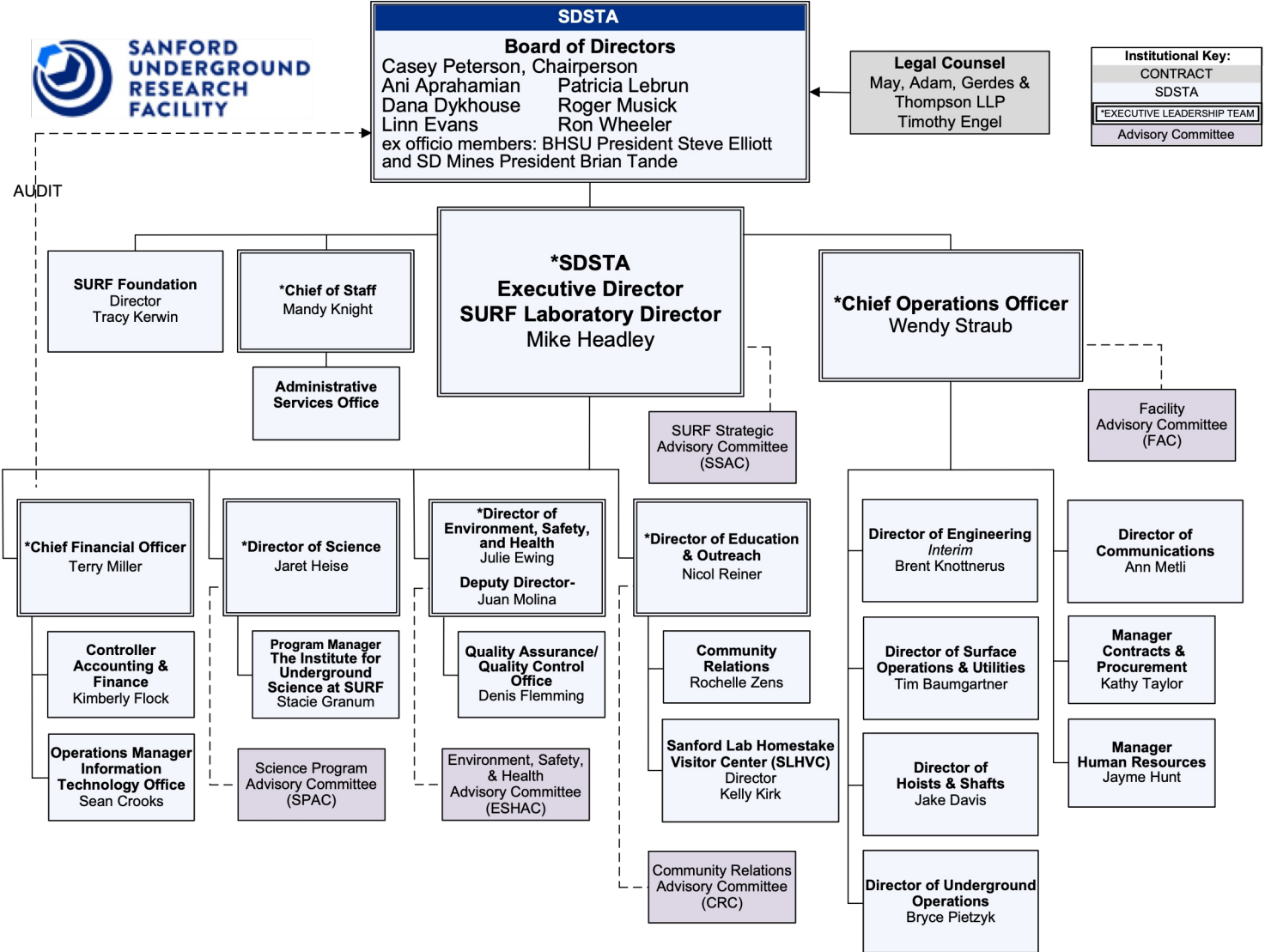
SURF Underground Lab Geography

Largest footprint for science: access to rock mass of $\sim 35 \text{ km}^3$, 35 km of tunnels



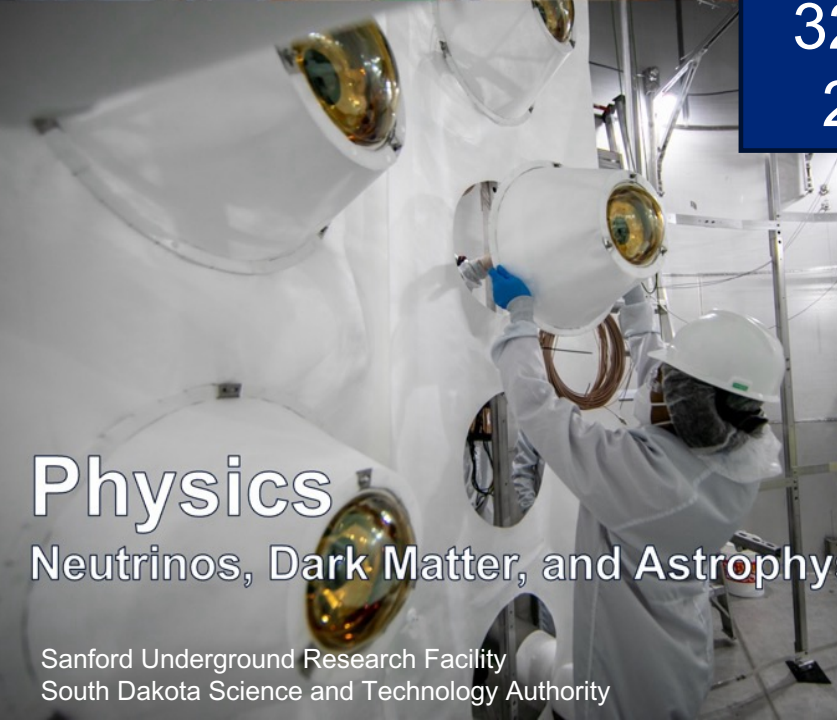
SDSTA Organization

Robust organization: 9 depts, 5 offices + Institute, Visitor Center and Foundation



Staffing Area	Current # ppl (%)	FY29 # ppl (%)
Admin / Mgmt	30 (13%)	30 (13%)
Engineering	13 (6%)	13 (6%)
ESH	21 (9%)	21 (9%)
Outreach	23 (10%)	23 (10%)
Scientific	5 (2%)	5 (2%)
Technical / Operations	133 (59%)	140 (60%)
TOTAL	225	232 *

* More LBNF/DUNE support possible
Current Science Direct Support = 19 ppl



Geology and Engineering

Enhanced Geothermal Systems
Mining Technology

Biology

Extremophiles, Biodiversity

Science Program

32 Expts with 1,730 Collaborators,
280+ Institutions in 47 Countries

Physics

Neutrinos, Dark Matter, and Astrophysics

Partnerships

Commercial, Technology,
Industrial, Workforce development

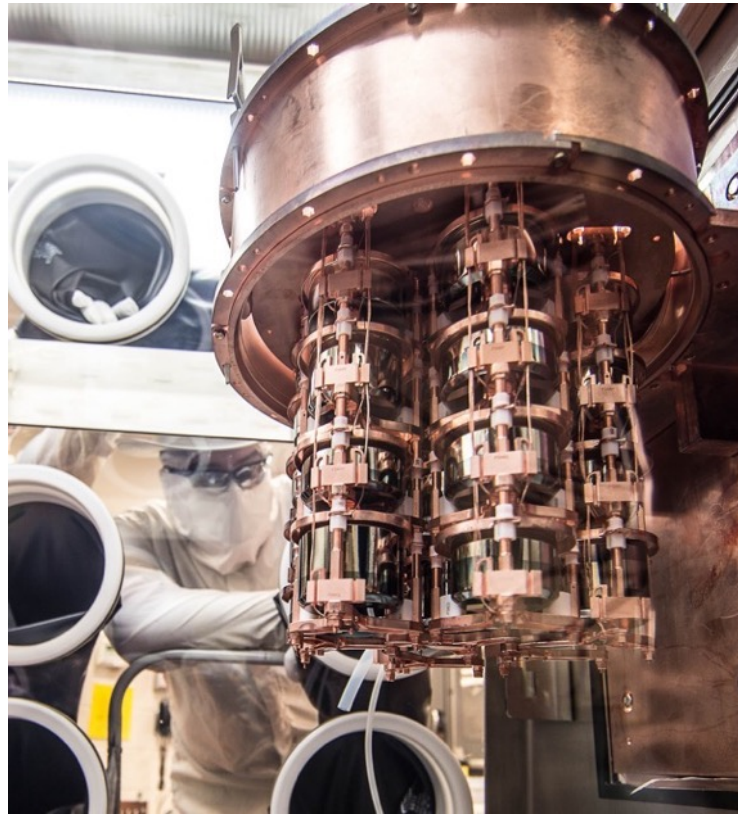
SURF Science Program – Current Physics Highlights

Strong and diverse program with exciting future



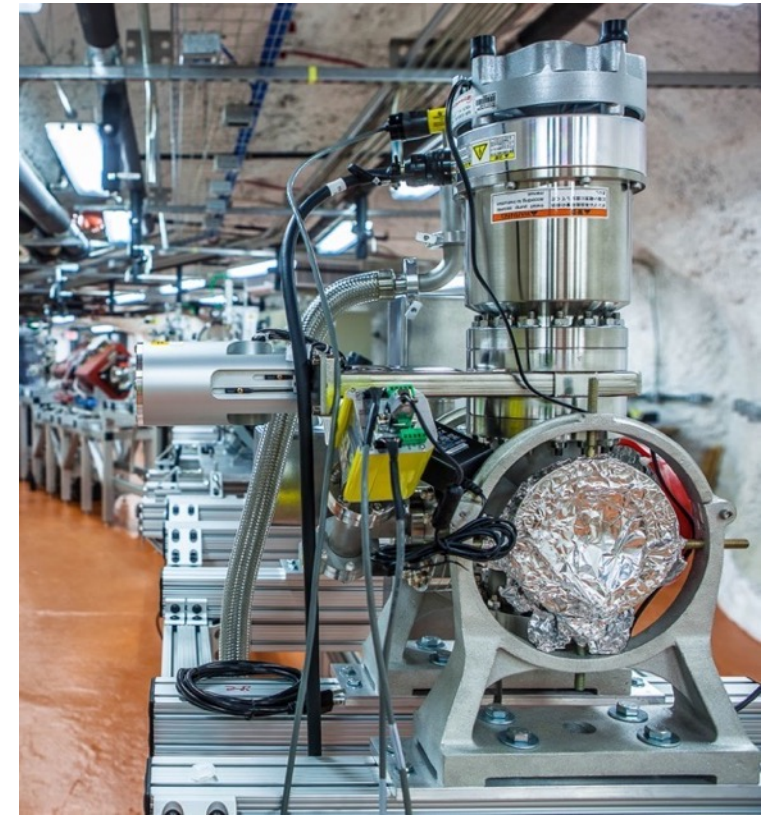
LUX-ZEPLIN (LZ)

- Direct search for **dark matter** using 10 tonnes xenon
- World-leading WIMP-search results announced 2022, 2024 + 2025 (^8B ν)



MAJORANA DEMONSTRATOR (MJD)

- Investigate **neutrinoless double-beta decay** using 44 kg Ge
- Ge-76 DBD and Ta-180 decay searches complete, decom under way



CASPAR

- Stellar fusion reactions to study **nucleosynthesis** using accelerator
- Initial phase 2015-2021, next phase started in 2025, last for 3+ years



SURF User Association

<https://sanfordlab.org/surf-user-association> (incl registration)

Purpose

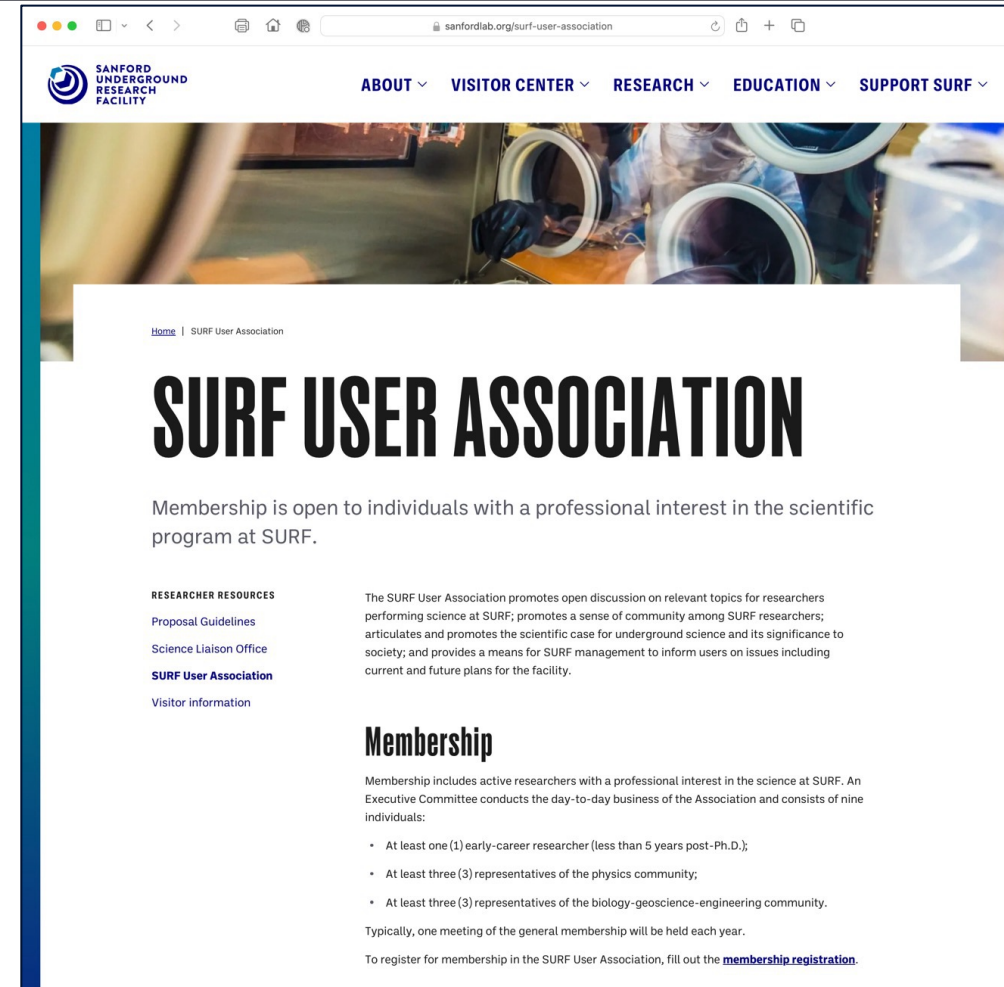
- **Two-way communication** on topics important to researchers
- Promotes a **sense of community** amongst SURF experiments and researchers
- Articulates and promotes **scientific case for UG science** and significance to society, provides channel for **advocacy**

Organization

- **Membership = 537** (open to all UG science community)
- **Executive Committee** consists of 9 individuals across scientific disciplines, incl early career. Quarterly meetings with SURF Management

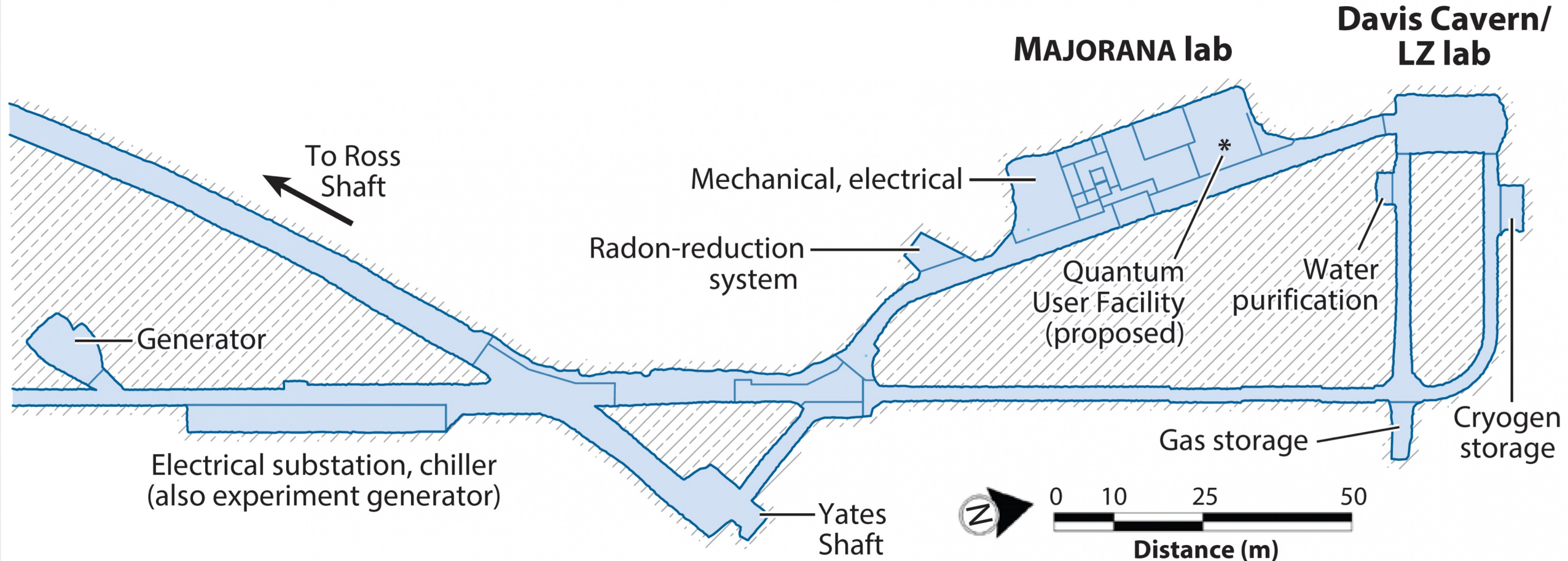
Events

- **Engagement** initiatives in progress, stay tuned in 2026
- **General meetings** typically annually, last @ CoSSURF 2024
- **Topical workshops**, incl community planning (e.g., Vision2021)
- **Advocacy**, with participation in 2026 HEP DC Visit (interactions with 27 congressional offices + OSTP)



SURF 4850L Davis Campus

3,017 m² (Total) / 1,018 m² (Science)



SURF 4850L Davis Campus

Examples of laboratory space



Detector Room (MJD):

Area = 140 m^2 , $11 \text{ m} \times 9.8\text{-}12.8 \text{ m} \times 2.7 \text{ m (H)}$
(raised section: $5.9 \text{ m} \times 5.8 \text{ m} \times 3.2 \text{ m (H)}$)



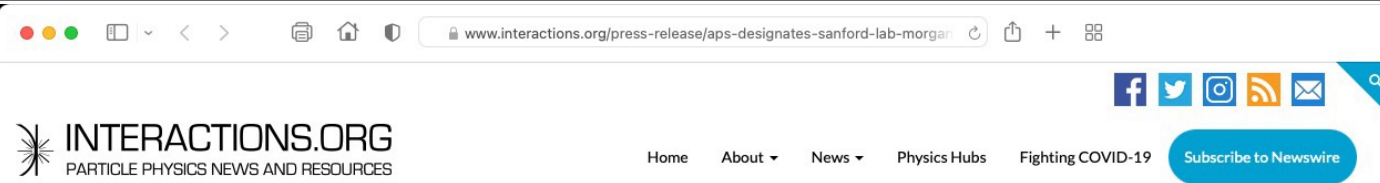
Davis Cavern, Lower (LZ):

Area = 142 m^2 , $13.7 \text{ m} \times 9.1 \text{ m} \times 6.4 \text{ m (H)}$
(incl tank: $7.6 \text{ m dia.} \times 6.4 \text{ m H}$). Total Cavern H = 10.8 m



SURF Designated APS Historical Site

Announcement Sep 2020, Dedication May 2022



APS designates Sanford Lab, Morgan State University as historic physics sites

14 September 2020 - Sanford Underground Research Facility

The pioneering neutrino research done by Ray Davis over nearly three decades forever changed our understanding of the Standard Model of Physics



The American Physical Society (APS) today announced it has designated SURF one of two Historic Sites in physics. The other, Morgan State University in Baltimore, Maryland, is recognized as the birthplace of the National Society of Black Physicists (NSBP).

DATE ISSUED:

September 14th, 2020

SOURCE:

Sanford Underground Research Facility

CONTENT:

Press Release

CONTACT:

Constance Walter
Communications Director
cwalter@sanfordlab.org



From 1962 to 1994, Raymond Davis Jr. built and operated the first successful detector for solar neutrinos using John N. Bahcall's theoretical model and working with William A. Fowler, Maurice Goldhaber, and numerous engineers and crew members on the 4850 Level of the Homestake Mine, now the Davis Campus at the Sanford Underground Research Facility. The result of Davis's observations, just one third the theoretical expected flux, led to fundamental advances in particle physics and astrophysics. For his work, Davis received a share of the 2002 Nobel Prize in Physics, along with Masatoshi Koshiba for his research into the detection of cosmic neutrinos.

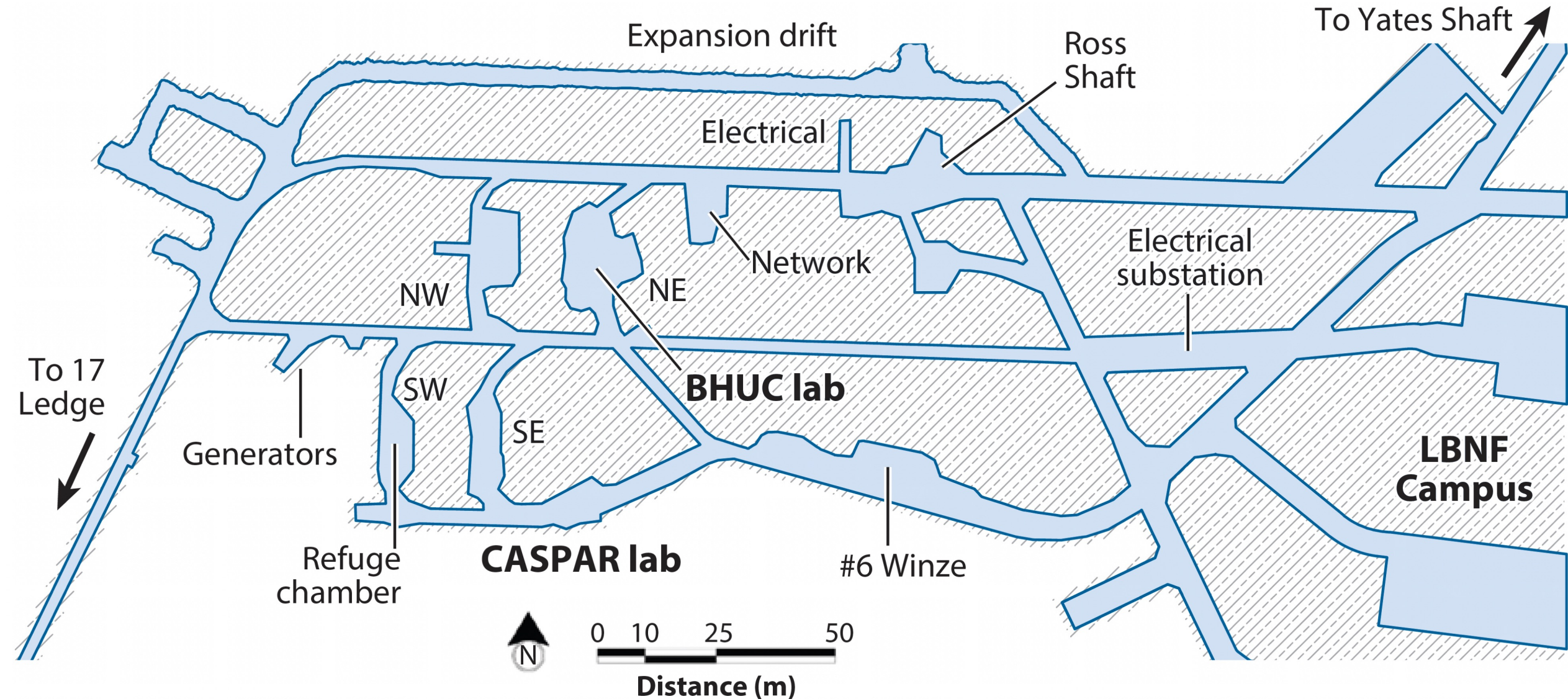


HISTORIC PHYSICS SITE, REGISTER OF HISTORIC SITES
AMERICAN PHYSICAL SOCIETY



SURF 4850L Ross Campus

2,653 m² (Total) / 920 m² (Science)



SURF 4850L Ross Campus

Examples of laboratory space



2010-2017

Former MJD Electroforming:

Area = 228 m²
(Cleanroom removed,
current construction office)

CASPAR Hall:

Area = 236 m²,
30 m × 3 m (min) × 2.8 m (H)



Copper Electroforming



2015-2021, resumed 2025



2015-2020, resumed 2025

BHUC Cleanroom:

Cavern Area = 268 m²,
Cleanroom = 12.1 m × 6.1 m ×
2.4 m (H)



SURF Material Assay at BHUC

Low-background counting capabilities serving national & international community



SURF Material Assay at BHUC

Low-background counting capabilities serving national & international community

Detector	Crystal		[U] mBq/kg	[Th] mBq/kg	Status	Comments
	Type	Size				
Maeve (LBNL)	p-type (85%)	2.2 kg	0.1 (10 ppt)	0.1 (25 ppt)	Production assays	Relocated from Oroville. Old Pb (200-yr old) inner shielding.
Merlin (LBNL)	n-type (115%)	2.2 kg	~0.2 (~20 ppt)	~0.2 (~50 ppt)	Operating	Installed 2025.
Morgan (LBNL)	p-type (85%)	2.1 kg	0.2 (20 ppt)	0.2 (50 ppt)	Production assays	Low-bkgd upgrade 2015.
Mordred (USD/CUBED, LBNL)	n-type (60%)	1.3 kg	0.7 (60 ppt)	0.7 (175 ppt)	Production assays	Low-bkgd upgrade 2015-2016, shield access upgrade.
Twins (Dual HPGe) (LBNL, BHSU, UCSB)	p-type (2x120%)	2x 2.1 kg	~0.01 (~1 ppt)	~0.01 (~1 ppt)	Operating	Low-bkgd upgrades 2016-2017; flexible shield configuration.
RHYM+RESN (Dual HPGe) (LLNL)	p-type (2x65%)	2x 1.1 kg	<0.1 (<10 ppt)	<0.1 (<25 ppt)	Production assays	Cryocooler, low-E ²¹⁰ Pb (<2 mBq/kg).
Ge-IV (Alabama, Kentucky)	p-type (111%)	2 kg	0.04 (3 ppt)	0.03 (8 ppt)	Offline	Gantry + hoist for vertical design. Awaiting relocation to Ross Campus.

Also see: LZ Assay Paper <https://arxiv.org/pdf/2006.02506>

Local universities have some additional material screening capabilities: **HPGe** ([0.2-0.4 kg]/SD Mines), **ICP-MS** (BHSU), **Rn emanation** characterization (0.1 mBq/SD Mines), **Alpha** (1 mBq/m² ²¹⁰Po/SD Mines; XIA UltraLo-1800/LZ purchased)



SURF Experiment Implementation & Support

Framework for establishing relationships and expectations with experiments

Experiment Implementation Program

- Integral to the SDSTA institutional mission is advancement of **compelling underground research**, implemented in **effective** and **efficient manner**
- Groups requesting **significant resources** or **significant changes** to facility capacities and/or capabilities may be subject to external review and evaluation
- Several key elements:
 - Experiment Planning Statement
 - User Agreement [space commitment] (references Publications)
 - Access (Request form, risk waiver, insurance)
 - Experiment Decommissioning Statement

Experiment Integration & Support

- In partnership with experiment, SDSTA aims to maintain a robust **organization** with **resources** to promote **safe and successful experiment** operations at SURF (consistent w/ CA baseline support)
- Several key elements:
 - Several specific ESH Standards (incl Work Planning)
 - SURF Applications/Databases (TAP, SARF, etc)
 - Table of responsibilities (SDSTA and Experiment)
 - Perception Survey, Information for Researchers, etc



Experiment Implementation Program



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For more details, see COSSURF 2024, User Association Session: <https://indico.sanfordlab.org/event/68/sessions/160/#20240516>

Rev. 04
SCT-1000-S-001
Experiment Implementation Program



**SANFORD
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SOUTH DAKOTA SCIENCE AND TECHNOLOGY AUTHORITY

Experiment Implementation Program

Rev. 06
SCT-1000-S-002
Experiment Integration & Support



**SANFORD
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SOUTH DAKOTA SCIENCE AND TECHNOLOGY AUTHORITY

Experiment Integration & Support

South Dakota Science and Technology Authority

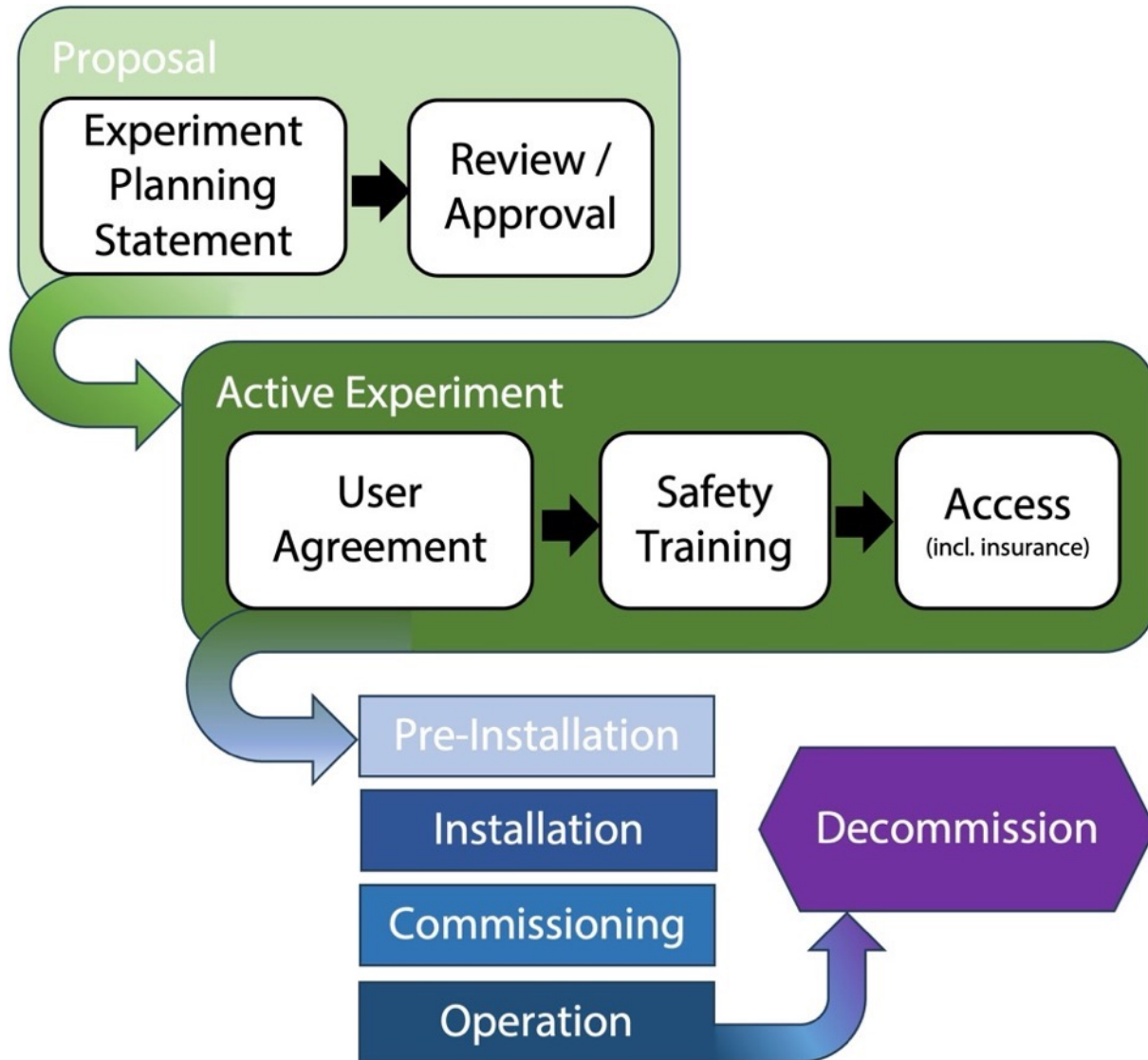
Page 1 of 9

Standard



SURF Experiment Implementation Program

Identify interfaces and hazards within approval framework



<https://sanfordlab.org/proposal-guidelines>

The screenshot shows the SURF Research Proposal Guidelines webpage. The header includes the SURF logo and navigation links: ABOUT, VISITOR CENTER, RESEARCH, EDUCATION, and SUPPORT SURF. The main heading is **RESEARCH PROPOSAL GUIDELINES**. Below this, it states: "All proposals must follow these guidelines".

RESEARCHER RESOURCES

- Proposal Guidelines**
- Science Liaison Office
- SURF User Association
- Visitor information

We are excited at Sanford Lab to contribute to cutting-edge science by providing the best environment for experiments that require unique underground facilities. We are glad to work with you to get your experiment running. To begin the process of approval and installation, follow the steps in the order listed below:

1. Read the [Experiment Implementation Program](#).
2. Read the [Experiment Integration and Support](#) document.
3. Complete a draft of the [Experiment Planning Statement](#) describing your project.
4. Contact the [SURF Science Director](#).
5. Complete the [User Agreement](#). The User Agreement references the SURF [waiver](#) required for underground access, the SURF [ESH Standards](#) and the SURF [Publication Policy](#).

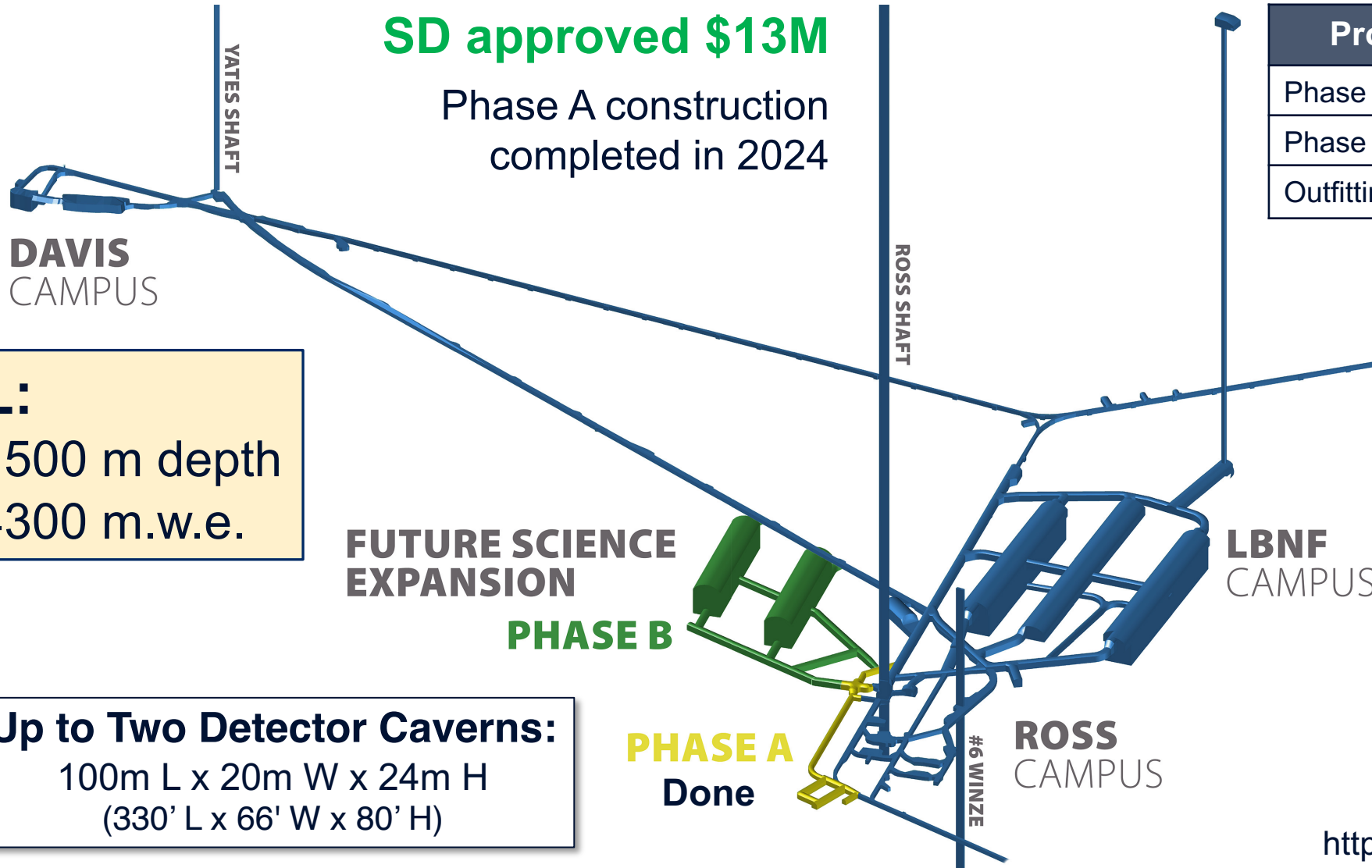
PROPOSAL DOCUMENTS

- SCI-(1000-S)-135416 Experiment Integration & Support.pdf
362.8 KB | PDF
- SCI-(1000-F)-69417 User Agreement
44.7 KB | DOCX
- SCI-(1000-F)-34460 Experiment Planning Statement
74.2 KB | DOCX
- SCI-(1000-F)-212612 User Agreement Acknowledgement.docx
31.8 KB | DOCX
- SCI-(1000-S)-186874 Publication Guidelines.pdf
255.3 KB | PDF
- EL-(1000-F) Combined Acknowledgement of Risk and Waiver
152.2 KB | PDF
- SCI-(1000-S)-34478 Experiment Implementation Program.pdf
1 MB | PDF



Deep Space Needed for Future Experiments

U.S. strategic plan endorsed SURF expansion for neutrino and dark matter expts



Proposed Funding Model

Phase A	\$13M State of SD ✓
Phase B	\$100M Private
Outfitting	\$100M Federal/Private



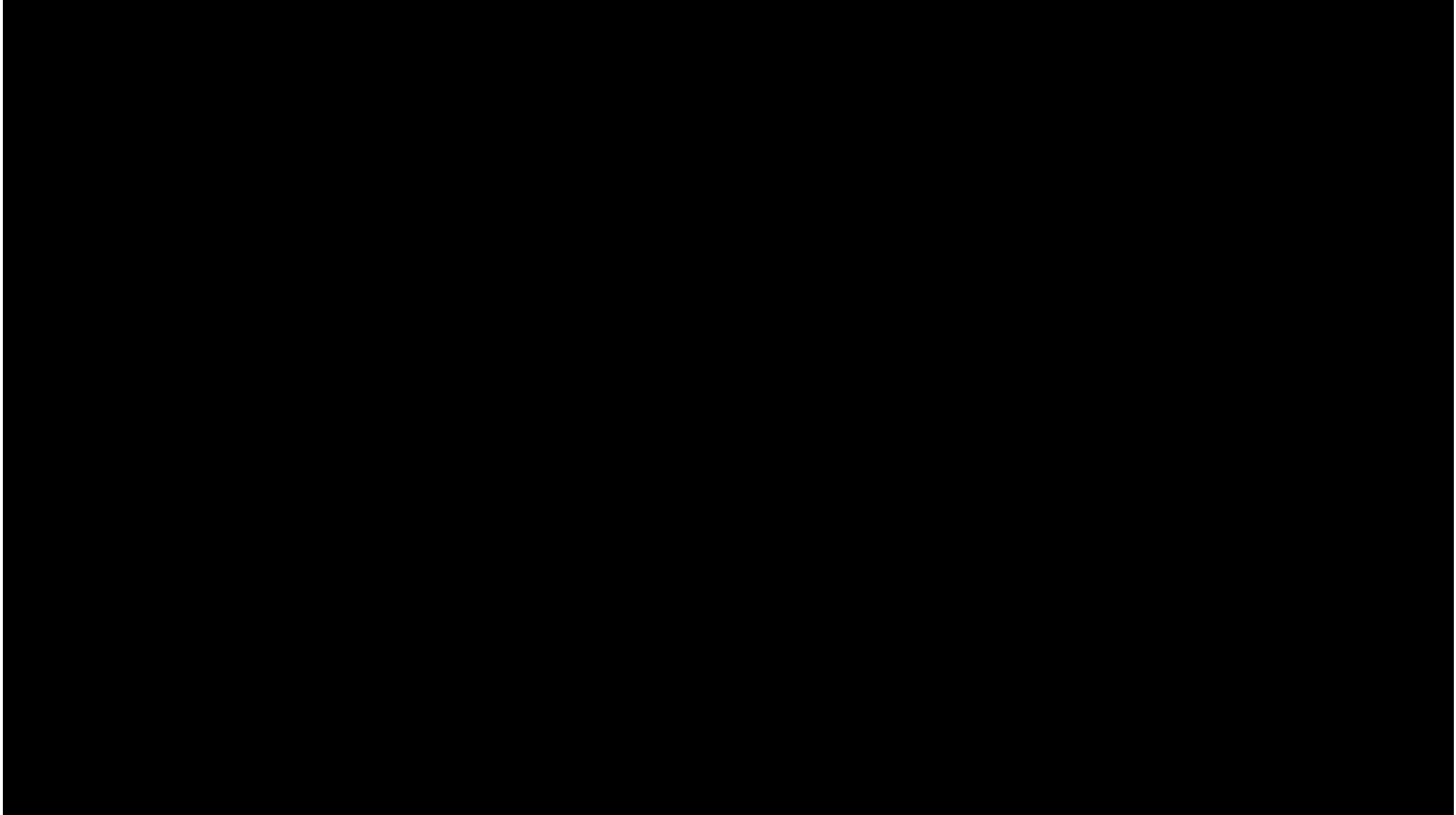
See also:

<https://arxiv.org/abs/2603.06504>



4850L Laboratory Expansion – Phase A

Expansion blasting video: <https://vimeo.com/982238458>



SURF Quantum User Facility

Multi-user, low-background, ultra-low temperature test facility

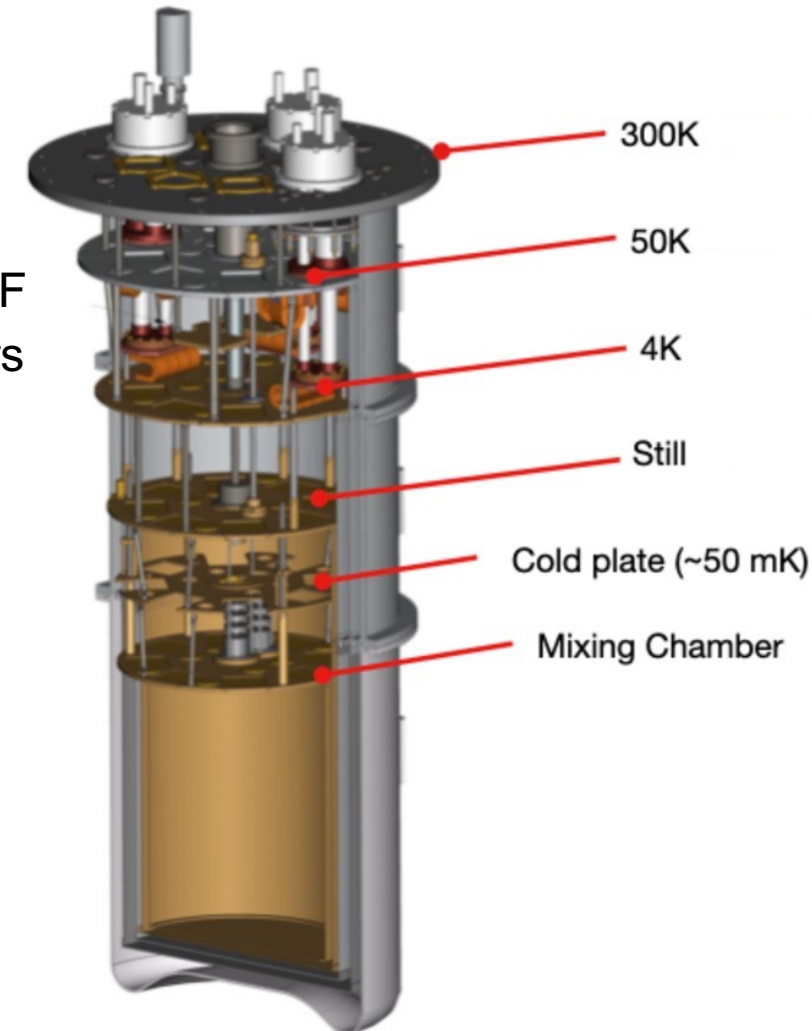
No deep underground cryogenic facility currently exists in the U.S.

Establish internationally-competitive research resources

- Detectors with extremely low energy thresholds and excellent energy resolution require isolation from ionizing radiation at deep facility like SURF
- Serve experiments using cryogenic calorimeters, quantum phonon sensors for applications in particle astrophysics, incl dark matter, $0\nu\beta\beta$, CEvNS
- Attract industry leaders in quantum computing (Google, IBM, D-Wave)
- Bolster \$3M investment in SD Center for Quantum Information Science & Technology

Planning underway

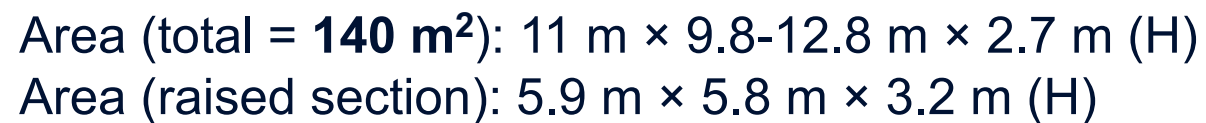
- Quantum Partnership Workshop (2026 event 3rd in series: <https://indico.sanfordlab.org/e/Quantum2026>) enhancing synergies with state QIS initiatives as well as broader interest in topics such as quantum communication networks
- Facility upgrades understood (mainly electrical, cooling)
- Cleanroom space available, also Pb shielding



Several options for commercial dilution refrigerator that would meet user needs

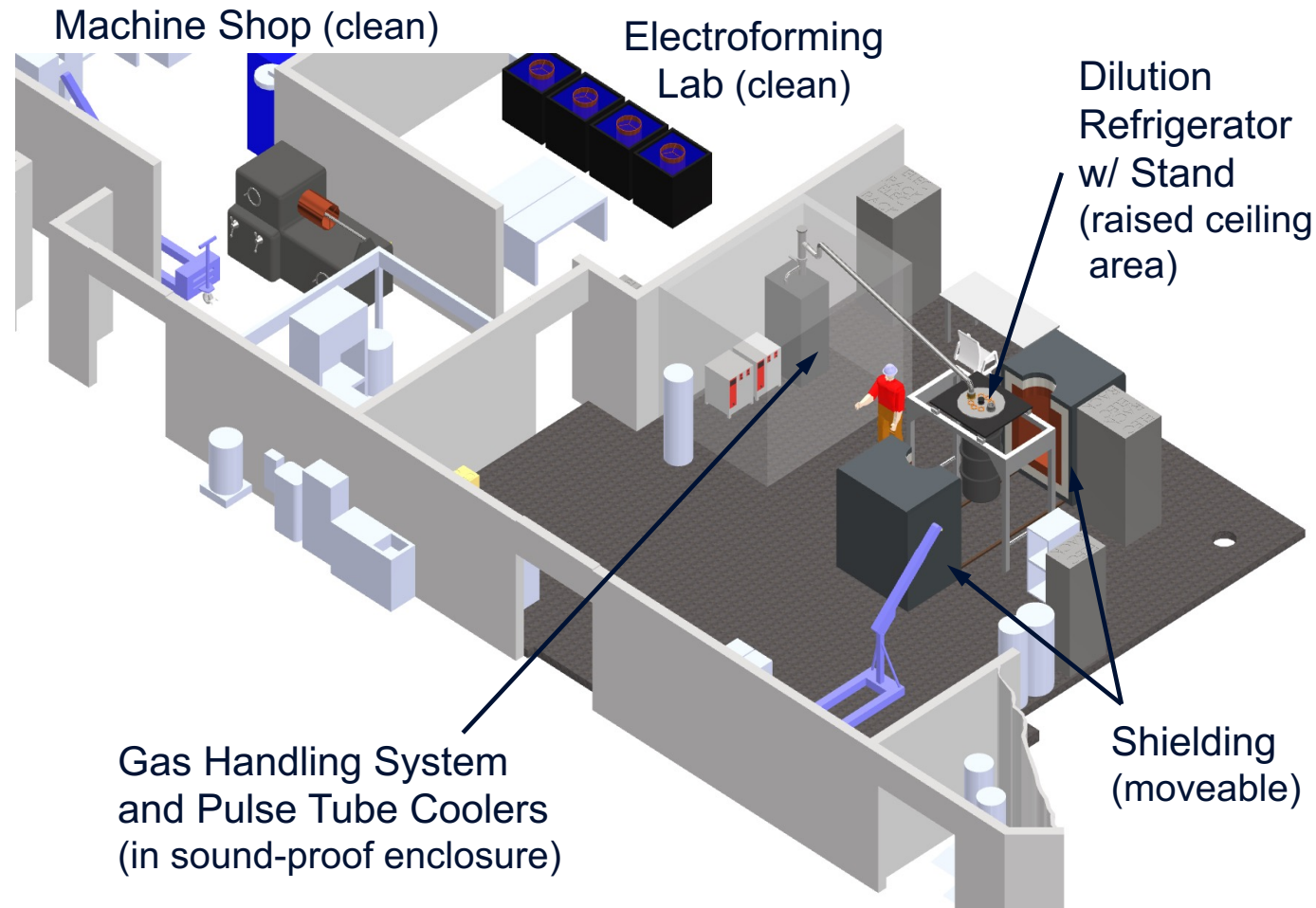


Deep site at 4850L Davis Campus planned to support range of quantum science



SURF Quantum User Facility

Deep site at 4850L Davis Campus planned to support range of quantum science



Area (total = **140 m²**): 11 m × 9.8-12.8 m × 2.7 m (H)

Area (raised section): 5.9 m × 5.8 m × 3.2 m (H)



Sanford Underground Research Facility

Thank You!



Agency Acknowledgement:

The Sanford Underground Research Facility (SURF) is a federally sponsored research facility under DOE-SC HEP Award Number DE-SC0020216 (cooperative agreement)



SURF Summary

- SURF has strong relationship with DOE that benefits UG science community:
 - SURF has mandate to **support experiments** and ensure **safe and reliable access for decades**.
- SURF offers world-class service to the underground science community:
 - SURF attributes attract **world-leading** experiments and scientists from **diverse scientific communities**.
 - SURF has **proven track record** of enabling high-impact science by leveraging strong **institutional partnerships**.
- SURF is playing a strong role in the UG science community:
 - **User Association** serving as catalyst for community discussions: <https://sanfordlab.org/surf-user-association>.
 - **Institute** has had significant impact with initial programming and building intellectual community.
- SURF wants to host future world-leading experiments:
 - LBNF excavation done, outfitting started in 2024. **DOE “Module of Opportunity”** expanded physics program.
 - Construction underway to **increase underground laboratory space**, plans advancing for new large caverns on 4850L on timeframe of **next-generation neutrino and dark matter experiments (~2030s)**.
 - Call for **Letters of Interest (LOIs)** re-affirmed prospective experiments and identified **new avenues**. New facilities in planning (Quantum User Facility) and consideration (Vertical Facility).
 - SURF is **deep laboratory** site and offers **largest footprint** in the world for scientific pursuits.

Many options to host future initiatives – big or small!



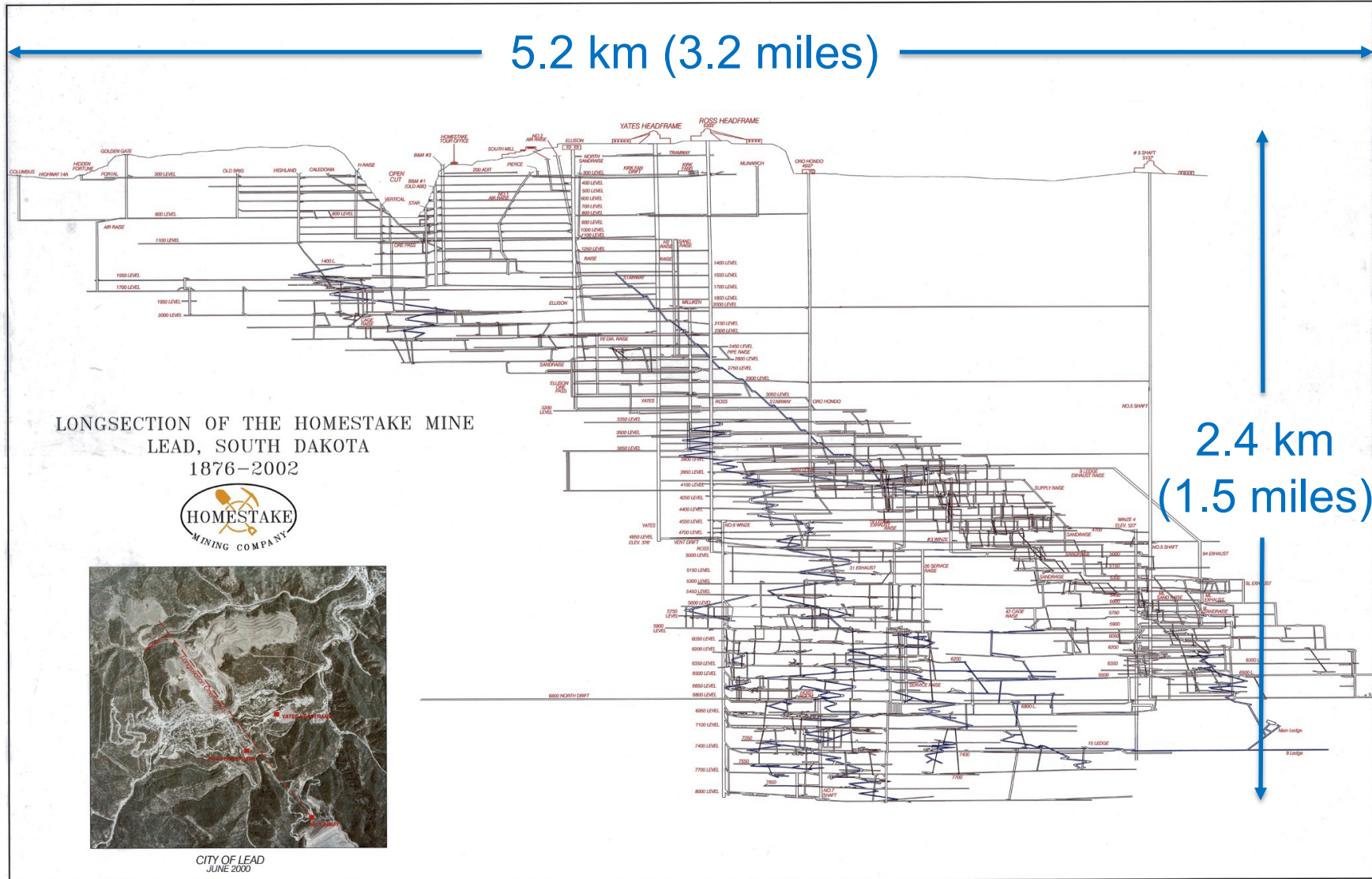
Sanford Underground Research Facility

Lead, South Dakota, USA



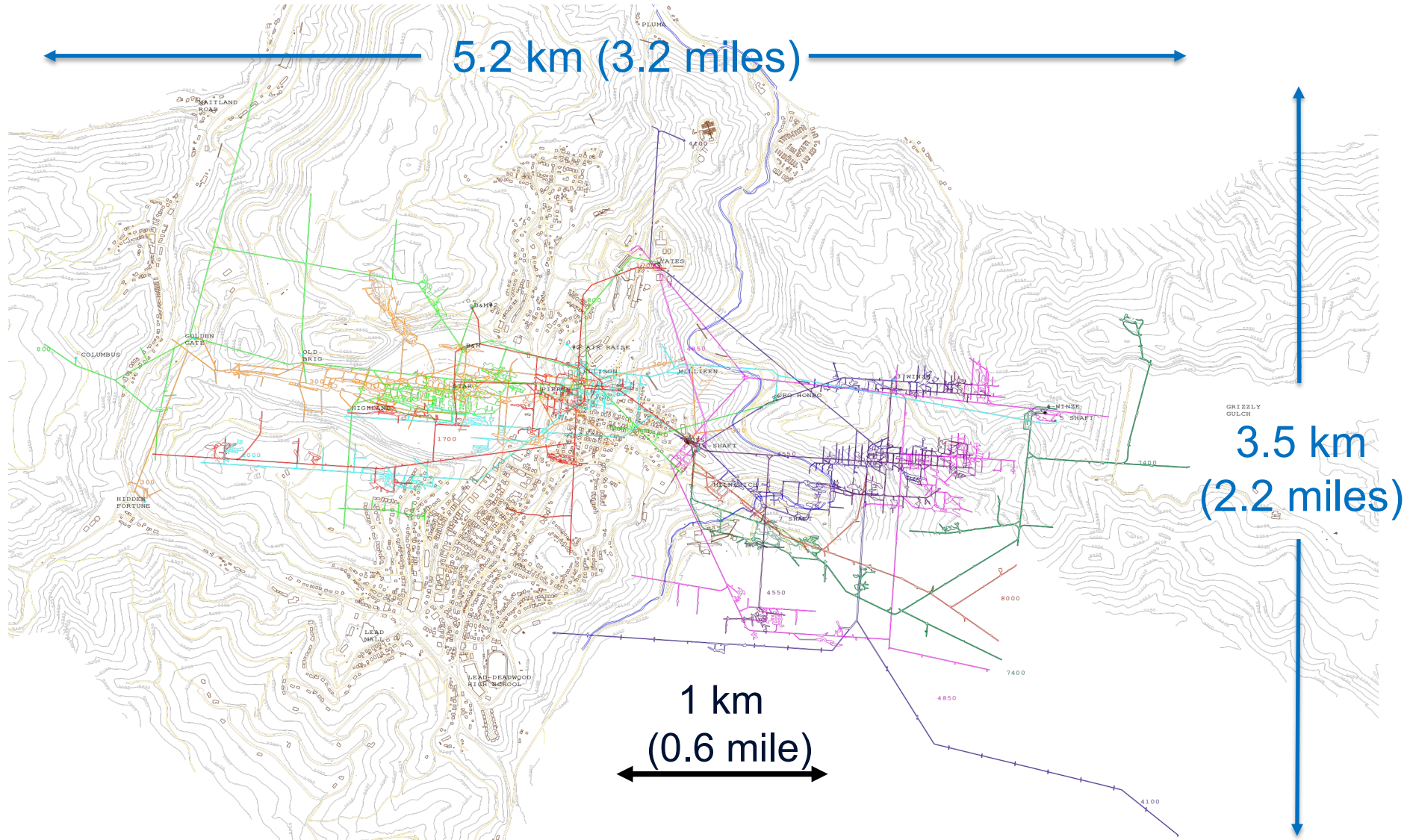
SURF Underground Lab Geography

Significant underground footprint for science



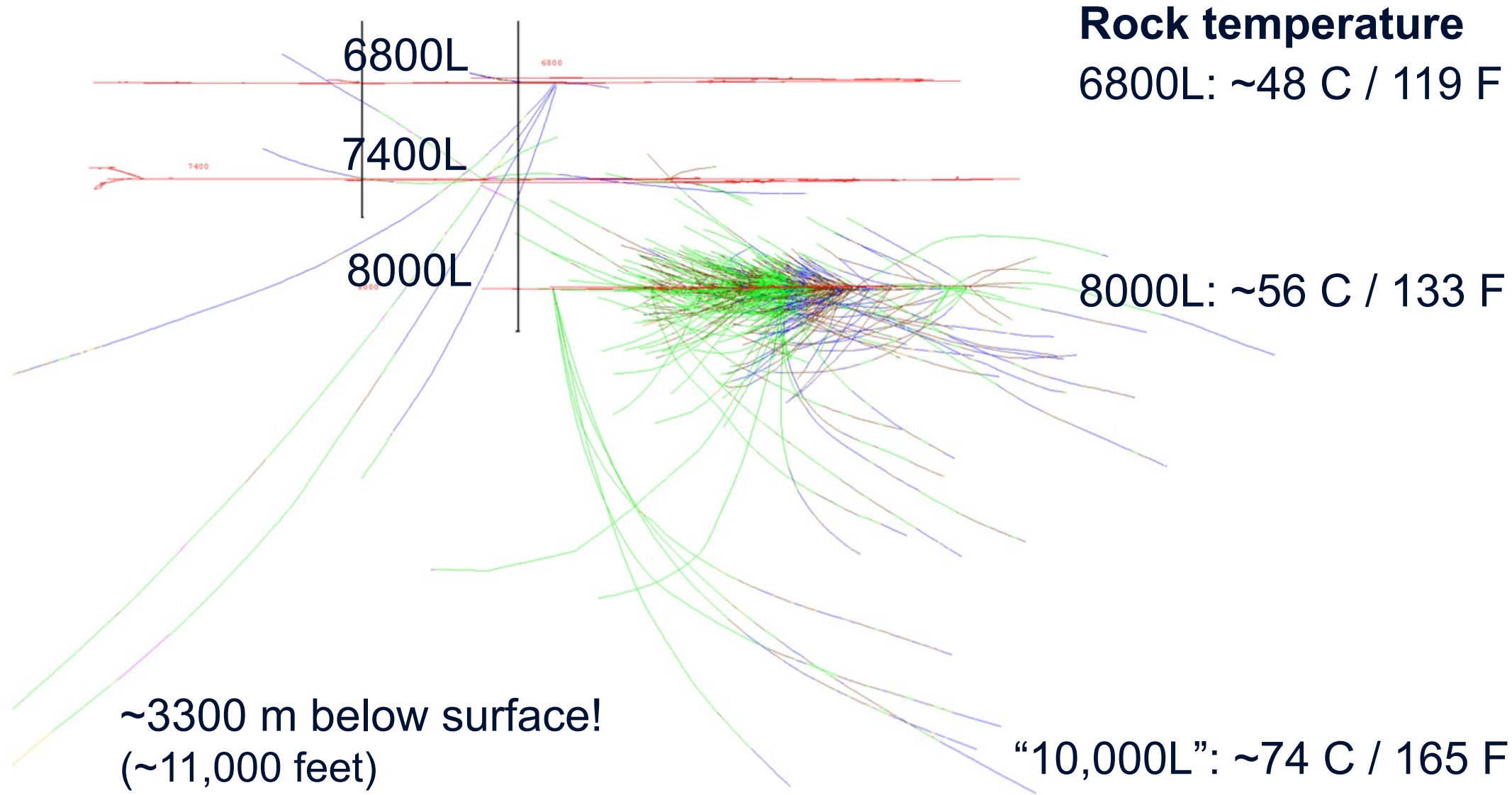
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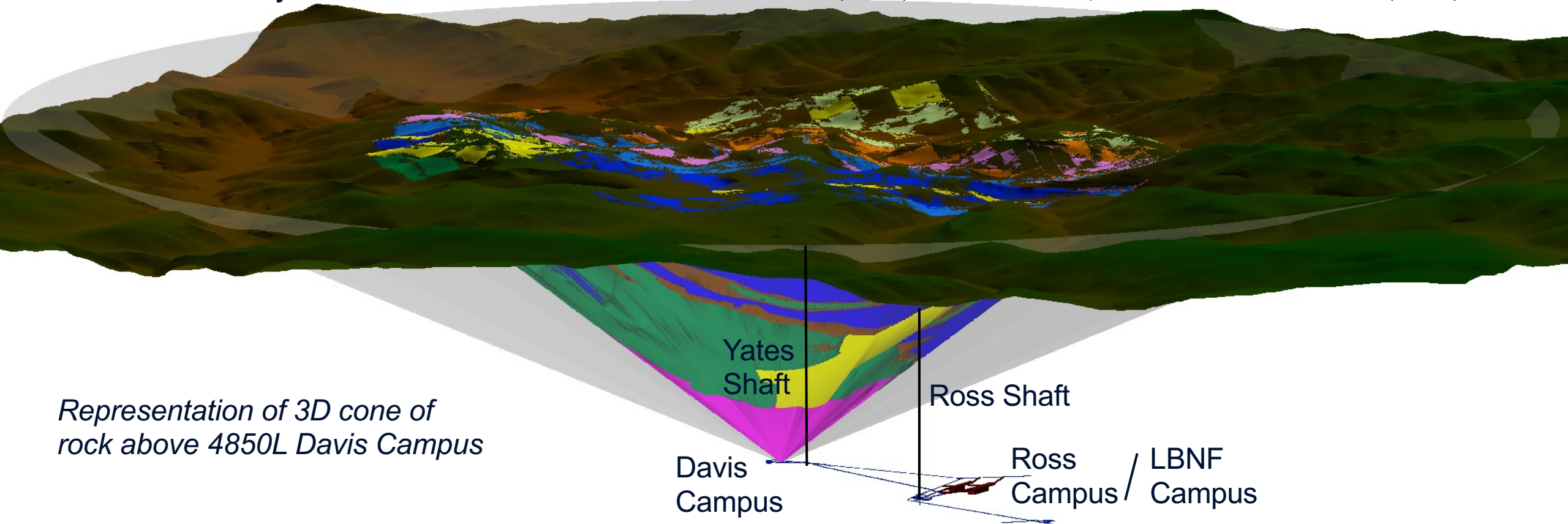
Future possibilities to access existing deep holes?



SURF Science Support – Geology Model

Site well understood, including drill core & logs

- 3D model of 12 rock formations (including rhyolite/phonolite intrusives)
- Detailed surface topology: Aerial survey for site performed 2011 (1' contours)
- Global coordinates: Survey performed summer 2016 (incl world's longest plumb bob)
- Rock density data: KH, TCT, WR, JH, *SD Acad Sci* **93**, 33 (2014); JH *ARNPS* in press - arXiv:2603.06504 (2026)



Long-Baseline Neutrino Facility (LBNF)

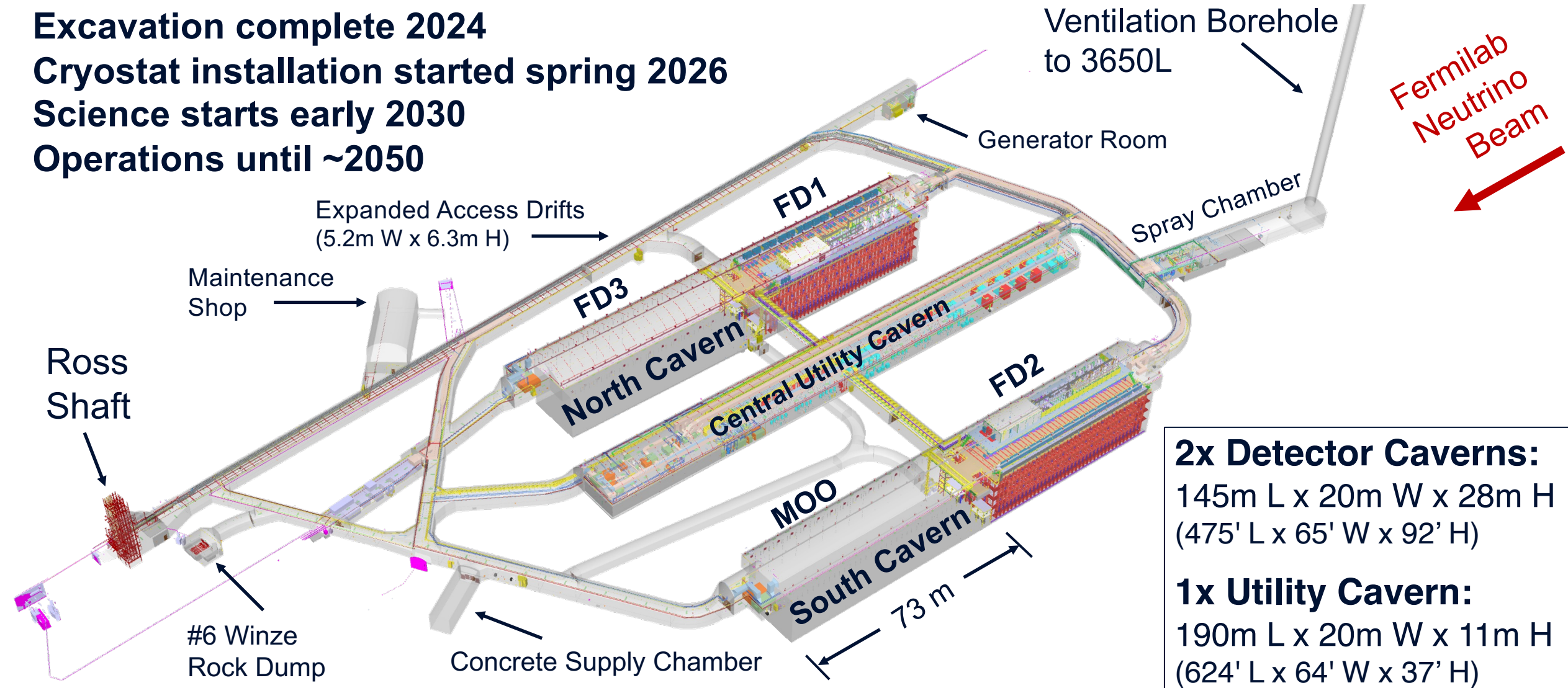
LBNF will host the Deep Underground Neutrino Experiment (DUNE)

Excavation complete 2024

Cryostat installation started spring 2026

Science starts early 2030

Operations until ~2050



LBNF South Cavern



LBNF North Cavern

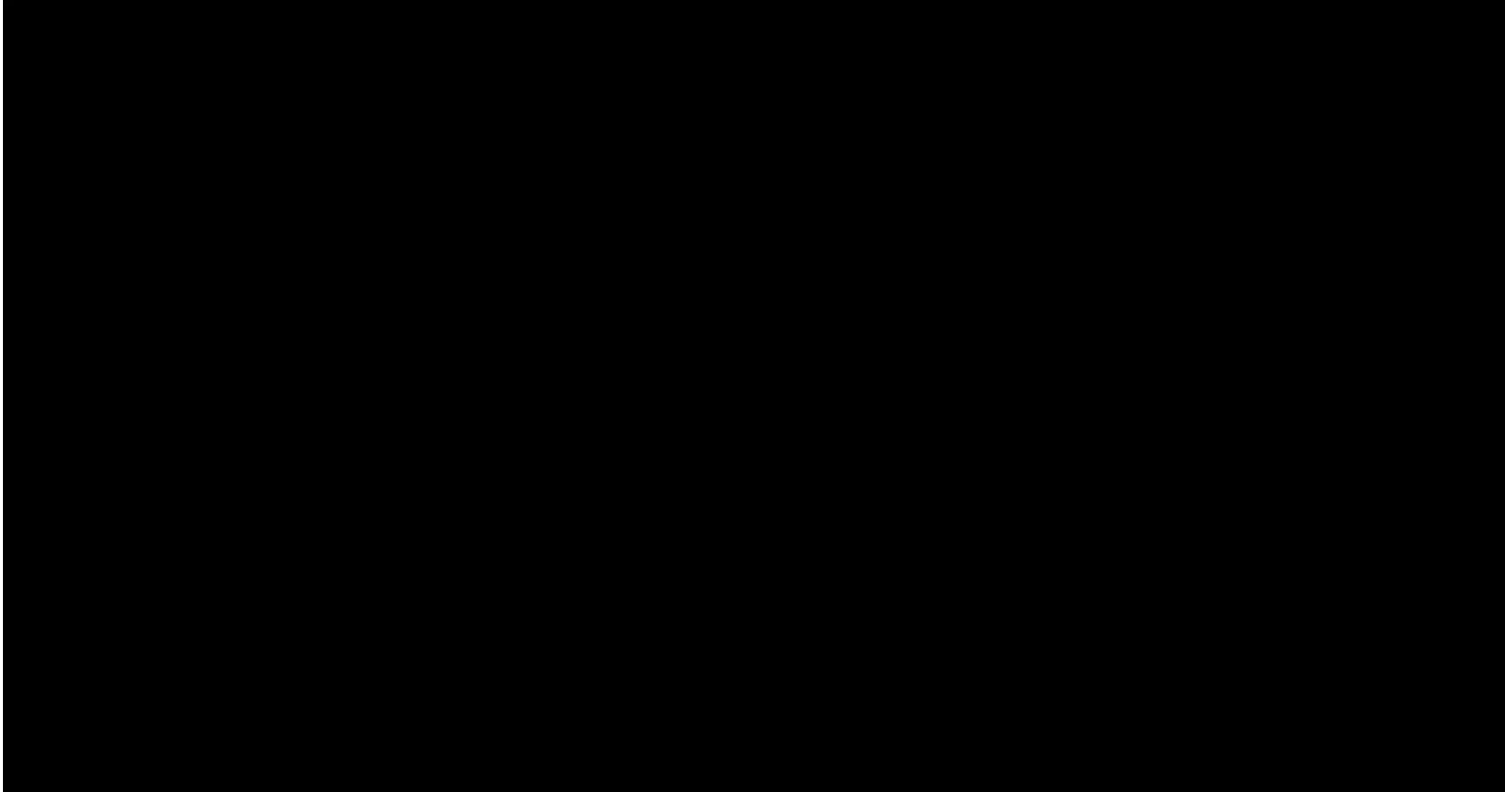




LBNF South Cavern

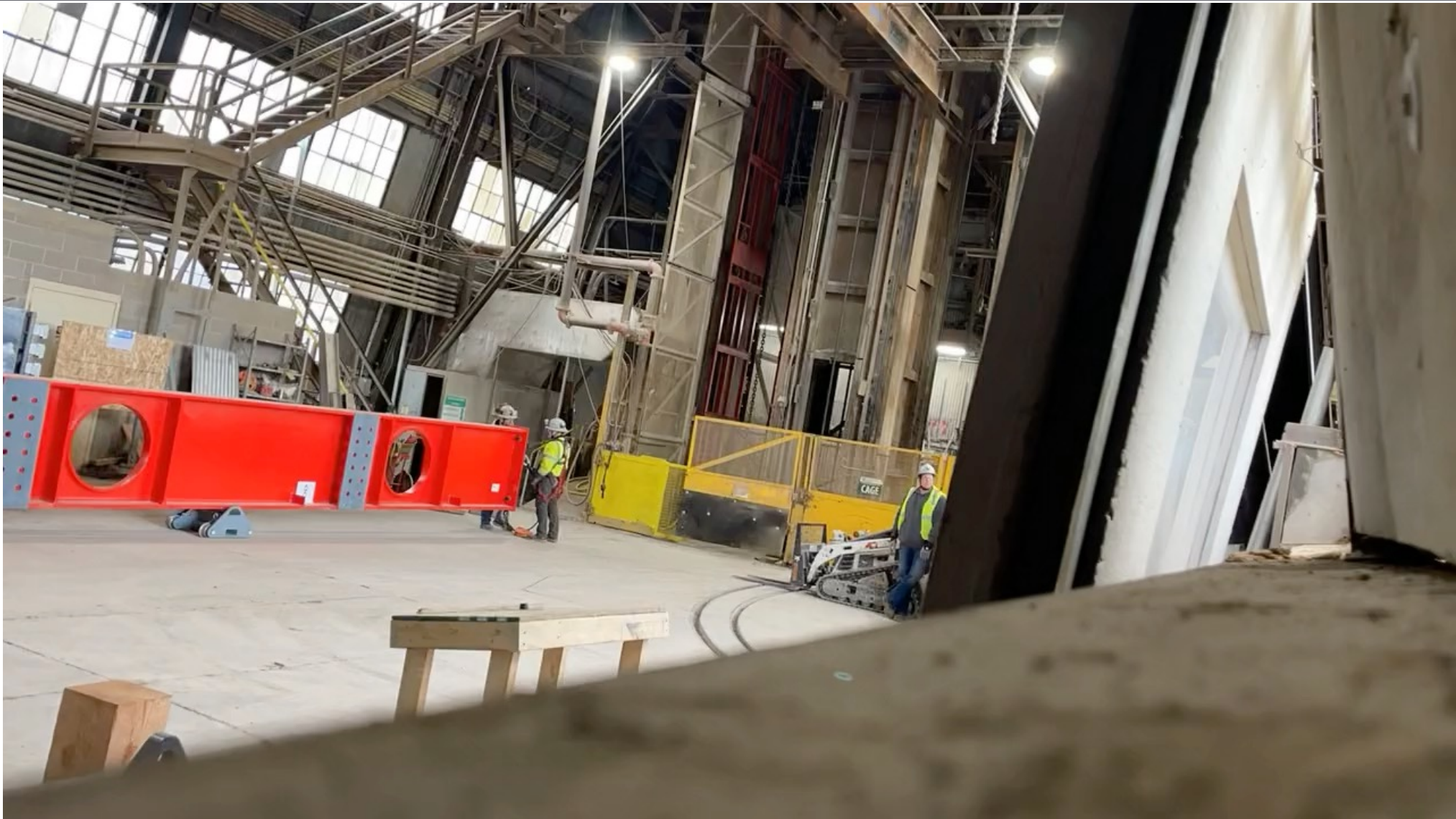
LBNF/DUNE Cryostat Installation Underway

Cryostat beam arrival video: <https://vimeo.com/1191695040/12915f8532>



LBNF/DUNE Cryostat Installation Underway

Cryostat beam loading video: <https://vimeo.com/1205831226/70989b0ee0>



SURF Site Ownership / Governance

- SDSTA is a quasi-state entity established by SD Legislature in 2004
 - Created to assume site ownership; manage indemnification, insurance, and risk management issues; and manage and operate SURF.
 - Reports to the SD Governor through the SDSTA Board of Directors.
- Site donation detailed in Property Donation Agreement (PDA)
 - Includes risk management and insurance (Risk Transfer Protocols).
- SURF governance:
 - State of South Dakota Office of Risk Management provides ESH oversight.
 - State of South Dakota DANR oversees environmental regulation compliance.
 - City of Lead is the AHJ for building and fire and life safety codes.
 - NRC regulates radioactive material.
 - Independent yearly financial audits and periodic internal controls audits performed.



SURF Governance

Informs SURF ESH Manual

- **Intergovernmental Agreement (IGA)** between SDSTA and state of South Dakota **Office of Risk Management (ORM)** for worker health and safety oversight at SURF:
 - Roles & responsibilities, incl site inspections and enforcement authority
 - Agreement on specific regulations, codes and standards that best support safe operations at SURF
 - Reviewed and approved annually (first version in 2011)
- Key IGA regulations include:
 - **OSHA:** General worker health (1910) and safety/construction activities (1926)
 - **MSHA:** Shaft and hoisting operations, ventilation, ground control (30 CFR Part 57), diesel particulate (Part 7), mine rescue (emergency response team)
 - **NFPA:** Electrical (70E), fire alarm (72), life safety (101), etc
 - **NEPA:** (10 CFR 1021)
 - **DANR:** South Dakota Dept of Agriculture and Natural Resources oversees environmental regulation compliance, also ionizing radiation-producing machine registration
 - **City of Lead** is AHJ for building, fire and life safety codes
- NRC regulates radioactive material:
 - License since 2013, amended 2018 for broad scope

INTERGOVERNMENTAL AGREEMENT
BETWEEN THE
BUREAU OF HUMAN RESOURCES AND ADMINISTRATION,
OFFICE OF RISK MANAGEMENT
OF THE STATE OF SOUTH DAKOTA
AND THE
SOUTH DAKOTA SCIENCE AND TECHNOLOGY AUTHORITY

This INTERGOVERNMENTAL AGREEMENT ("AGREEMENT") is made and effective the 1st day of July, 2026, between the South Dakota Bureau of Human Resources and Administration, 500 E. Capitol Avenue, Pierre, South Dakota 57501, and the South Dakota Science and Technology Authority, 630 E. Summit, Lead, South Dakota, 57754 ("SDSTA") pursuant to SDCL Ch. 1-24 and in particular SDCL 1-24-8.

Introduction and Purpose

The State of South Dakota established SDSTA to facilitate the development of the former Homestake gold mine into an underground science laboratory (the "Sanford Underground Research Facility" or "SURF") and to lead the operation of SURF. The mission of the SDSTA is "to advance world-class science and inspire learning across generations."

When operating as an active mine, the Homestake gold mine was regulated by the U.S. Mine Safety and Health Administration ("MSHA") and the South Dakota Department of Environment and Natural Resources ("DENR")¹. SDSTA received title to the Homestake site in 2006 from Homestake Mining Company of California after the 2003 closure of the mining facility.

MSHA and DENR continued to administer and enforce safety and environmental programs until 2008, at which time the SDSTA sought to clarify MSHA's regulatory role. MSHA determined at that time that it no longer had regulatory jurisdiction over the safety and health operations at the Homestake site due to the completion of mining reclamation and the new function of the site.

The U.S. Occupational Safety and Health Administration's ("OSHA's") 29 CFR 1926² and 29 CFR 1910³ are considered the most applicable of the available standards for safety and health for most activities conducted in support of the development and operation of SURF, except for the underground shafts, hoists, and ventilation systems. In these instances, MSHA's 30 CFR⁴ standards are employed (see Appendix A).

Although OSHA standards are being applied to the work conducted at SURF, OSHA does not have jurisdictional authority for enforcement of those regulations because SDSTA is for the purposes of OSHA standards and regulation a "political subdivision" as defined in 29 CFR 1975.5 because it is administered by individuals who are appointed by the Governor.

¹ Pursuant to Executive Reorganization Order 2021-03 DENR was merged with the South Dakota Department of Agriculture and is now referred to as Department of Agriculture and Natural Resources (DANR).

² Title 29 Code of Federal Regulations Part 1926, "Safety and Health Regulations for Construction"

³ Title 29 Code of Federal Regulations Part 1910, "Occupational Safety and Health Standards"

⁴ Title 30 Code of Federal Regulations Parts 15, 49, and 57"



SURF Operations Cooperative Agreement (CA)

- CA established a direct relationship between DOE and SDSTA.
- Original agreement included 5 years of SURF operations at \$125M total (Federal FY20-24).
- Under the CA, the SDSTA operates and maintains SURF in support of the science mission. Provides all personnel, facilities, equipment, supplies, and services. Manages the overall effort.
- CA scope includes “Basic Support” to approved Non-Proprietary users without charge. The user will pay for costs incurred for services over and above basic support.
 - e.g.: Users needing an exceptional amount of power pay the delta.
- Costs to support Proprietary users must be fully recovered per DOE direction.
- DOE funds SURF Infrastructure Improvement Projects to ensure safe and reliable operations.
- CA “renewal” for an additional five years awarded in Sept 2024 (FY25-29), adding \$208M. Additional \$6M appropriated by Congress for FY26 to begin Yates hoists upgrade.



SURF Aspires to Become DOE User Facility

Important to have deep underground user facility in the U.S.

Benefits

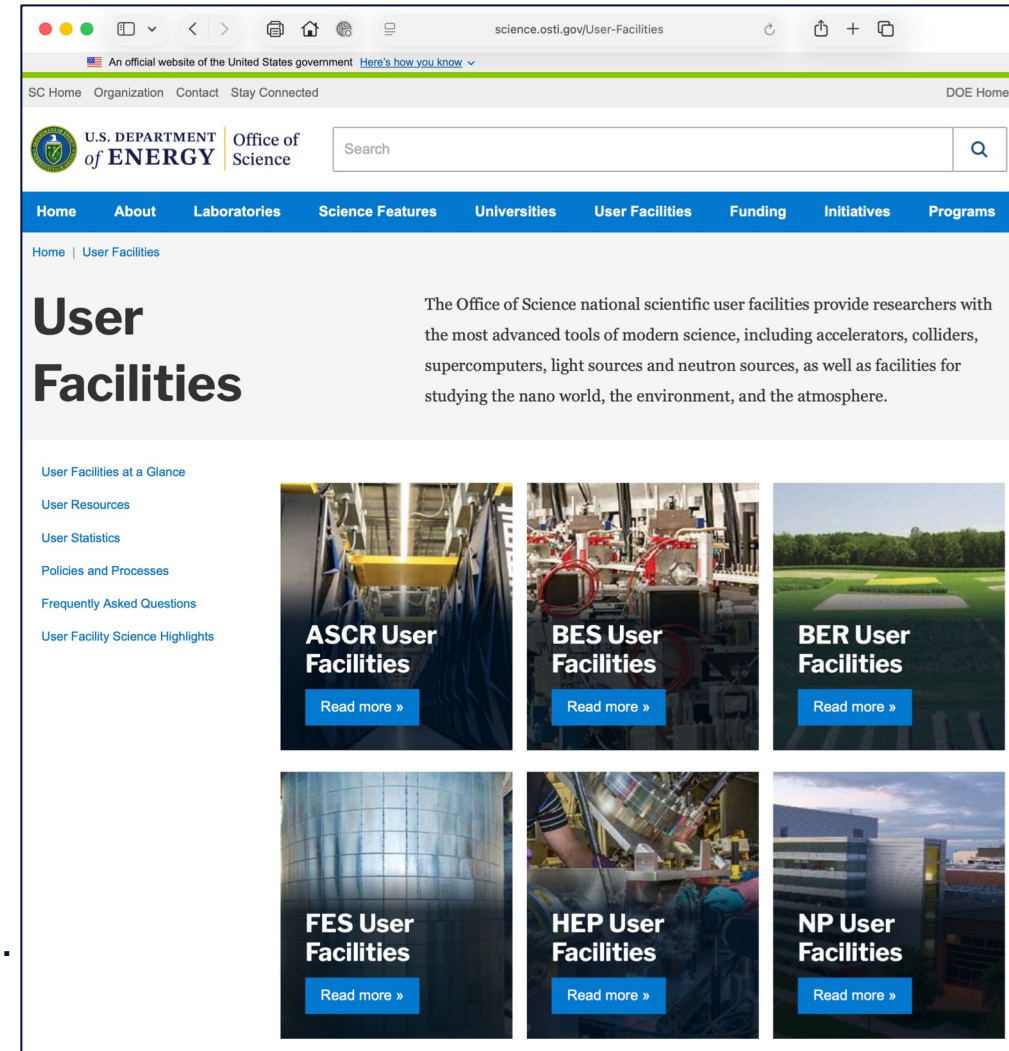
- Expands DOE User Facility portfolio to incl underground lab, raises SURF's stature within DOE community.
- Promotes underground science in U.S., increases SURF funding opportunities (FOAs encourage partnerships w/ User Facilities)
- Enhances SURF's role in global science community.
- Communicates SURF is open to a broad range of science and users, SURF processes for hosting science accepted by DOE.

Main Requirements

- Facility open to users regardless of nationality or institution. ✓
- Allocation of facility resources determined by merit review. ✓
- Facility resources for users to conduct work safely and efficiently. ✓
- The facility supports a formal user organization. ✓

Status

- User Association + Science Program Advisory Committee established.
- Significant maintenance for Yates Shaft completed March 2025.
- Application draft near final, awaiting DOE invitation to submit.



SURF Science Strategic Plan

Long-term vision to ensure SURF continues to serve scientific community

Goals

- **Program:** Attract world-leading scientists and experiments
- **Facilities:** Ensure SURF facilities support science program
- **Support:** Ensure organizational capabilities serve experiments
- **Engagement:** Establish strong SURF role in global UG science community

Physics (closely aligned with top U.S. national priorities)

- DUNE support (Phase 1 and Phase 2)
- Generation 3 Dark Matter (XLZD and/or ARGO)
- ‘Agile’ Experiments / Low-Mass Dark Matter
- General R&D facility
- Generation 2 Dark Matter upgrade (extend LZ ops + low-mass dark matter)

Quantum User Facility
w/ dilution refrigerator

Non-Physics (based on community expert input)

- SURF is critical hub for innovation and discovery:
 - Geology and geomechanics (geothermal, real-time sensing, etc)
 - Biology and microbial systems (extremophiles, incl CO₂ sequestration)
 - Industrial and academic partnerships (e.g., CAT, NSF REU programs, etc)



January 31, 2024

To: Kevin Lesko, SURF Science Strategic Plan Steering Committee Chair

Subject: SURF Science Strategic Plan Steering Committee Charge

The Sanford Underground Research Facility (SURF) need a long-range strategic plan supported by the scientific community to synchronize the schedule for new experiments and capitalize on additional underground space.

Goals of the SURF Science Strategic Plan include:

- **Science Program:** Attract world-leading scientists and experiments from diverse scientific communities
- **Science Facilities:** Ensure the capability and capacity of SURF facilities match the science program and support requirements
- **Science Support:** Ensure processes as well as organizational and other technical capacities serve experiments as appropriate to a world-class facility
- **Science Engagement:** Establish a strong role for SURF in the global UG science community and leverage community engagement to ensure that the SURF science program maintains a



December 15, 2024

To: William Roggenthen, Chair SURF Science Strategic Plan Steering Committee (Non-Physics)

Subject: SURF Science Strategic Plan Steering Committee (Non-Physics) Charge

The Sanford Underground Research Facility (SURF) needs a long-range strategic plan supported by the scientific community to synchronize the schedule for new experiments, to capitalize on additional underground space, and to facilitate fulfillment of the requirements of new projects.

Goals of the SURF Science Strategic Plan include:

- **Science Program:** Attract world-leading scientists and experiments from diverse scientific communities
- **Science Facilities:** Ensure the capability and capacity of SURF facilities match the science program and support requirements
- **Science Support:** Ensure processes such as organizational and other technical capacities serve experiments as appropriate to a world-class facility
- **Science Engagement:** Establish a strong role for SURF in the global UG science community and leverage community engagement to ensure that the SURF science program maintains a high level of excellence.

To be most effective, development of the SURF Science Strategic Plan is separated into two parts: physics and non-physics.

The SURF Science Strategic Plan is meant to inform a number of current and potential stakeholders:

- SDSTA
- Underground Science Community
- Funding agencies including but not limited to DOE, NSF, NASA, NIOSH, and potential industrial partners
- SDSTA/SURF Boards and Committees
- SURF Foundation (e.g., private donors).

Specific charge elements for the Committee include the following:

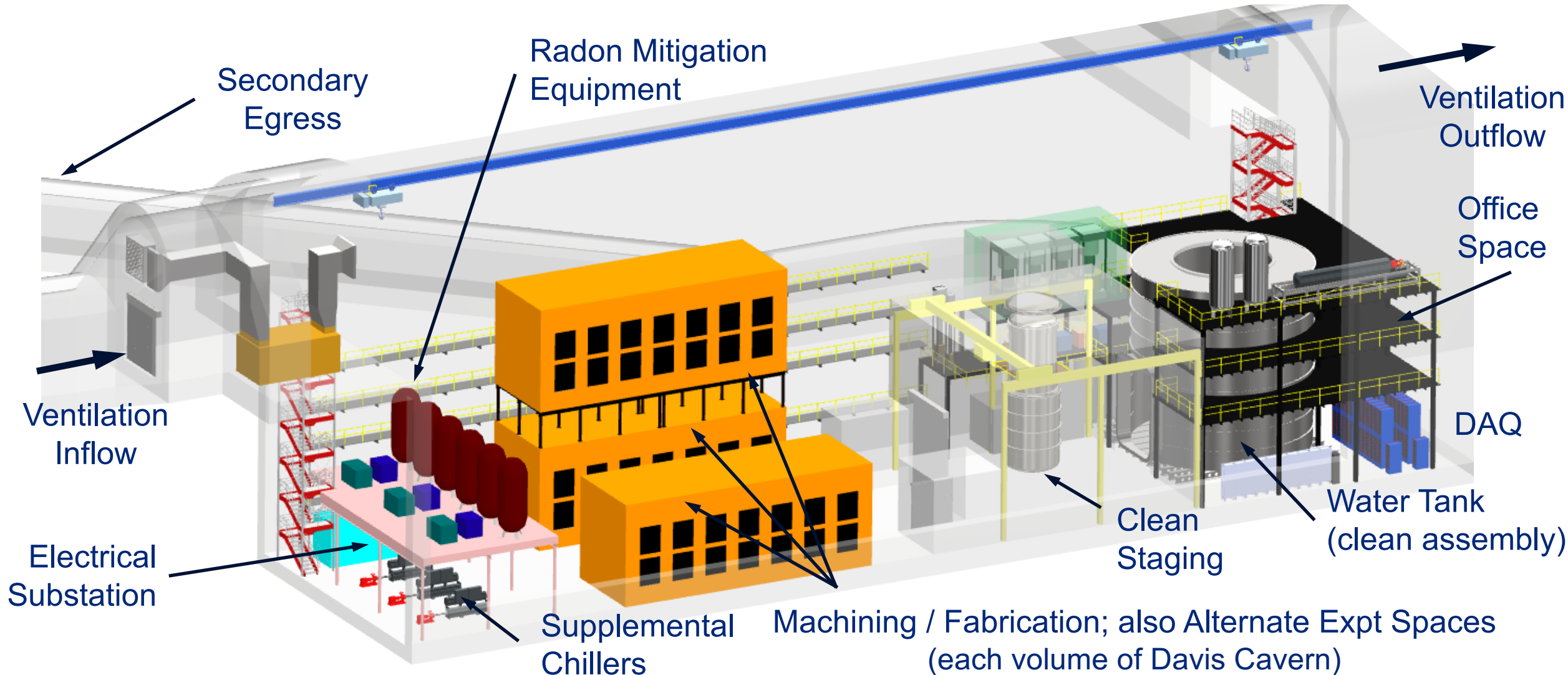
1. **Timeframe:**
 - a. Establish an appropriate period of time for the strategic plan (ideally ~10 to 15 years).
2. **Science Program:**
 - a. Organize Panels, including external experts as appropriate, to coordinate community workshops and other forms of outreach advertising SURF opportunities, the potential impact these opportunities may have on advancing the scientific disciplines in question, and clarifying SURF unique attributes.
 - b. In some cases where the discipline or researcher are new to the unique opportunities of the UG environment provided by SURF, the workshops may want to explore the possibility of an initial phase of exploratory experiments and assess the support and facilities that may be required to make this approach successful. Description of pathways for initiating research would be important.

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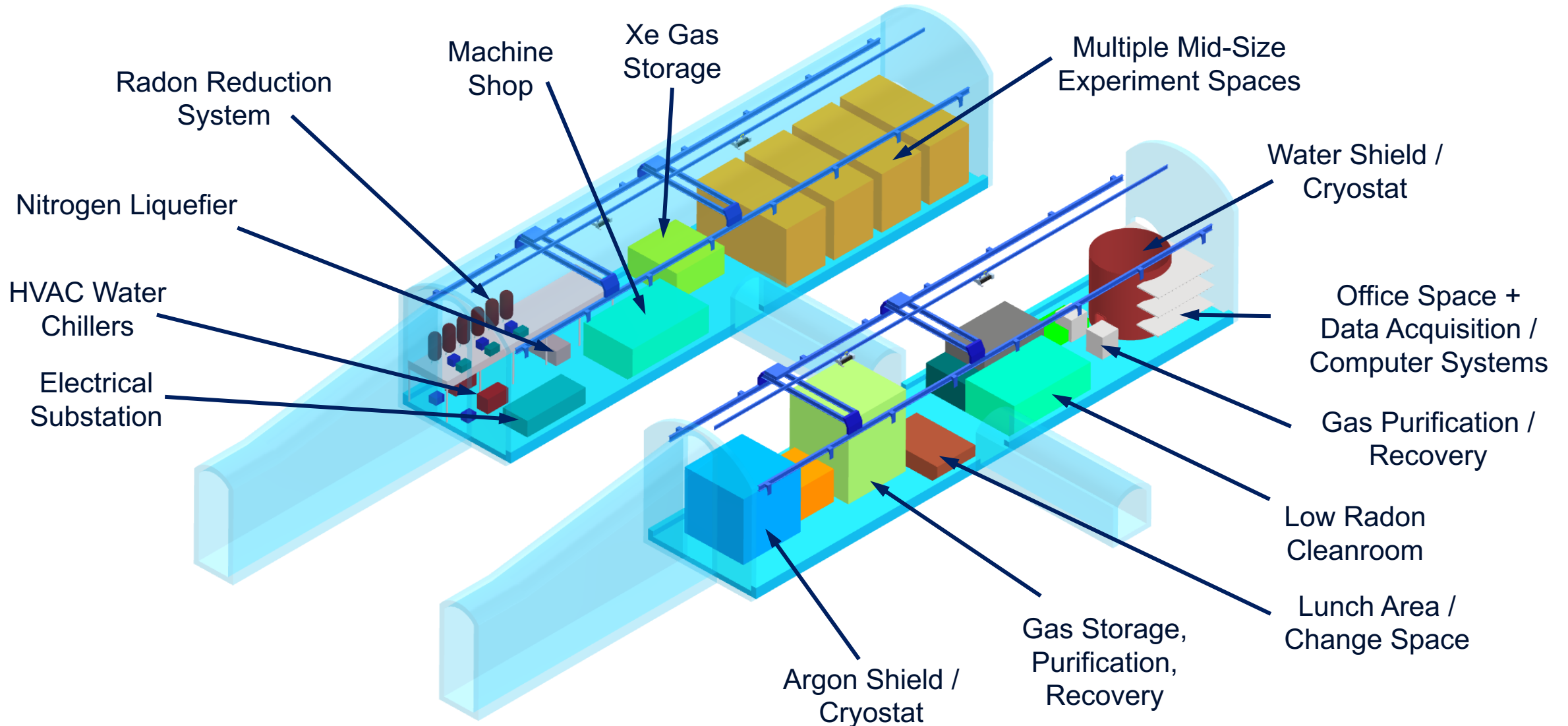
Next-Generation Science at SURF

Several deep options available



Next-Generation Science at SURF

Conceptual layout (2x 100m caverns), informed by DUSEL PDR, ARGO/XLZD, LZ



Next-Generation Science at SURF

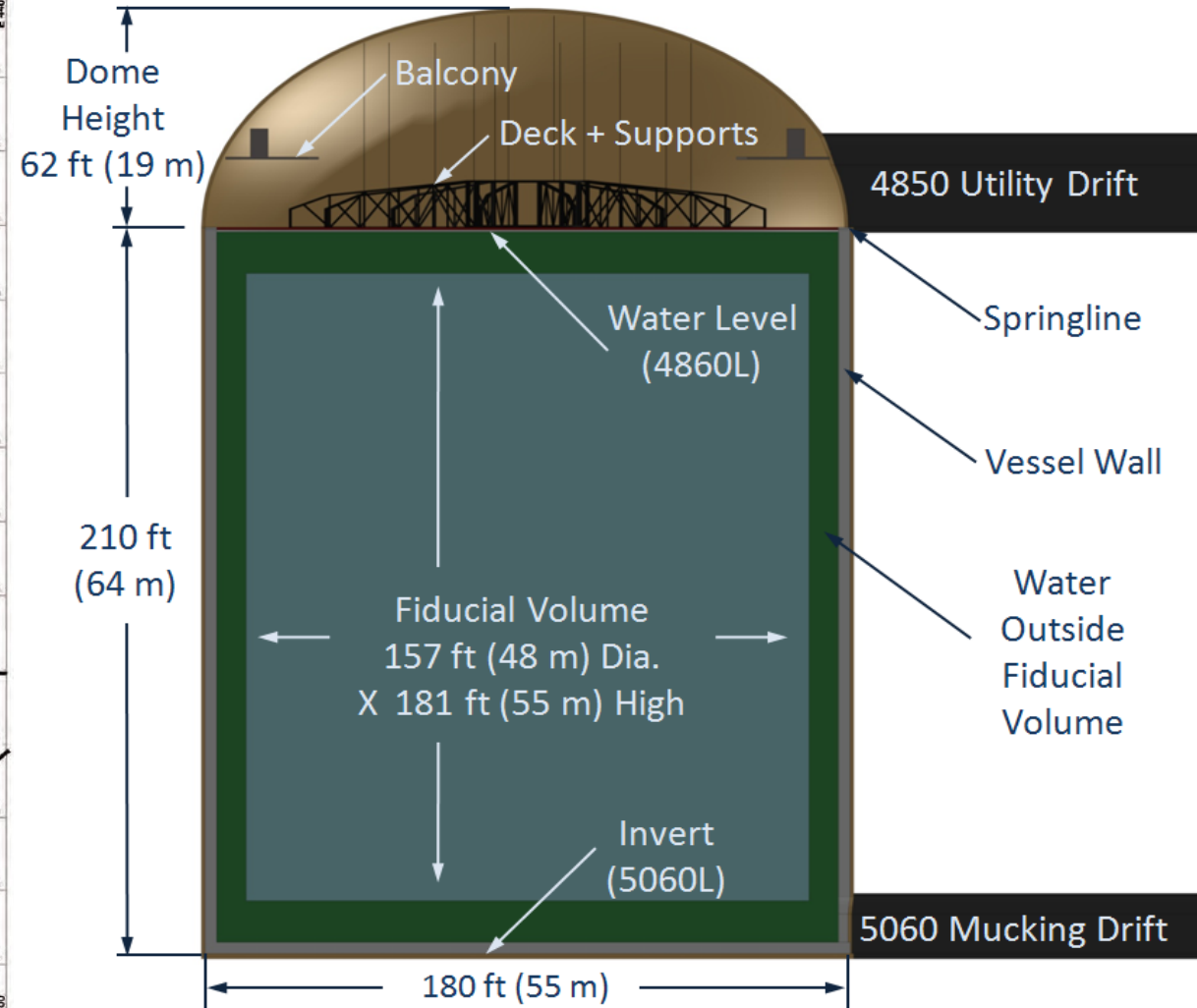
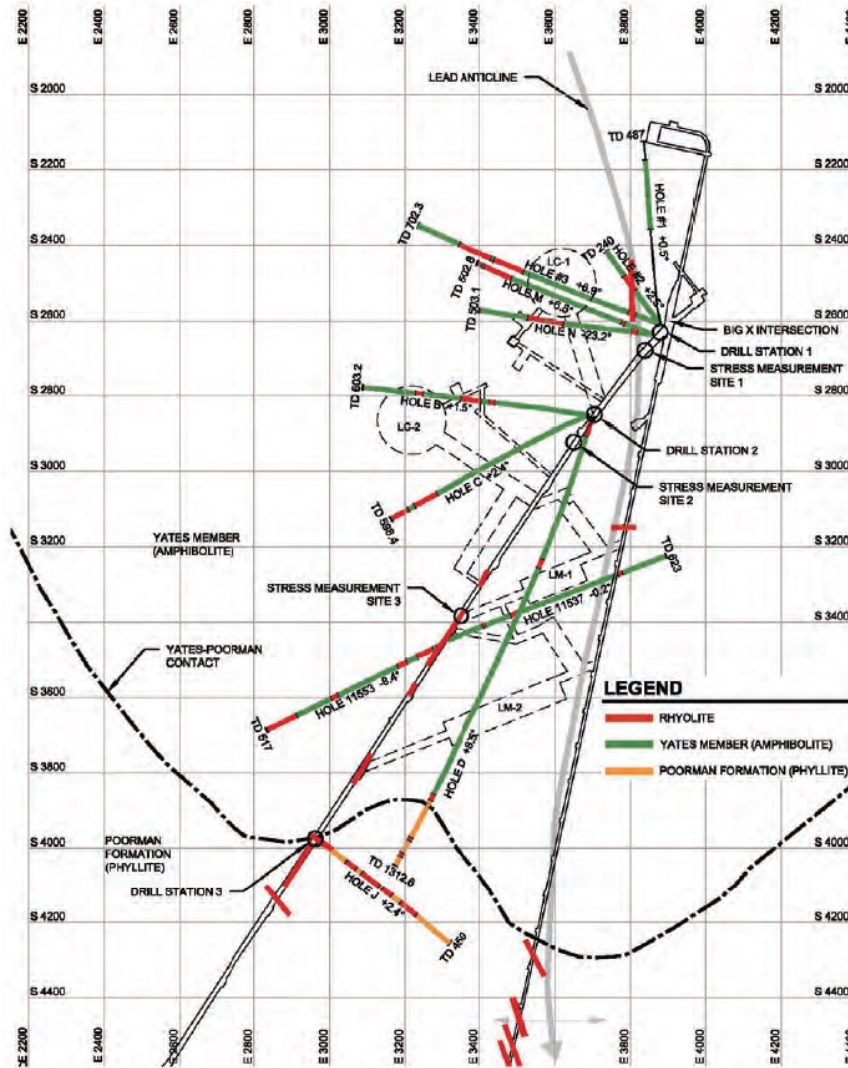
Several deep options available, alternate geometries possible

4850L Right Cylinder Studied

LBNE 100 kT
Water Cherenkov
(see DUSEL PDR:
[arxiv:1108.0959](https://arxiv.org/abs/1108.0959))

Ventilation

- **Exhaust:**
170,000 m³/h
(via raise to
4700L)
- **Fresh Air:**
30,600 m³/h
via Yates Shaft
(1 exchange/hr)



SURF Call for Letters of Interest

Ensuring SURF used to its fullest scientific potential

Significance of 2024 LOI Call:

- SURF's first formal call to UG science community since 2005!
- Initial calls selected strong physics anchors for Davis Campus: MJD and LUX (which led to current LZ)
- 2024 call is opportunity for SURF to advance scientific strategic plan goals, ensure strong science program continues

Overview of 2024 LOI Call:

- Open to all disciplines: Physics, Geology, Biology, Engineering
- Identifies specific existing space on 4850L and 4100L, other undeveloped areas may be available now
- 4850L Expansion started Mar 17, 2024, space available ~2030 (nominally two detector caverns: 100 m L x 20 m W x 24 m H, LOIs and subsequent discussions will inform final design)
- LOIs reviewed by SURF Science Program Advisory Committee
- Nominal deadline May 17, 2024, **LOIs still being accepted**

15 responses received, initial SPAC review complete



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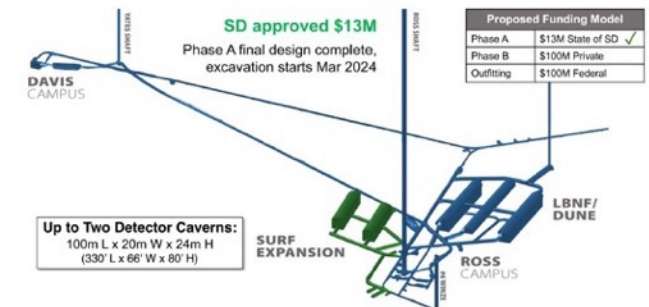
March 22, 2024

SURF Request for Letters of Interest 2024-01

Dear Researcher,

In support of our mission to advance world-class science, the Sanford Underground Research Facility (SURF) is seeking input from the global underground science community to ensure that scientific priorities are being accommodated and that SURF is being used to its fullest scientific potential.

SURF has a strong science program that currently comprises 29 experiment groups. Programs in some of our key 4850L laboratories are expected to complete in the next 1-4 years, which presents an opportunity to survey the community for new prospects. SURF is tremendously excited about new large laboratories that are being developed on the 4850L, with initial construction underway and space available on the timeframe of ~2030.



Leading into recent U.S. long-range planning, the SURF User Association held a Vision Workshop (<https://indico.sanfordlab.org/e/Vision2021>) and SURF participated in nuclear physics town halls and the particle physics Snowmass community input processes. As a result, SURF featured prominently in the strategic plans for both Nuclear (red) and High Energy Physics (red) communities. With the physics community long-range plans in-hand, SURF has set up a Steering Committee to distill opportunities and key elements relevant to the organization's science strategic plan (non-physics disciplines will also be addressed to inform the comprehensive strategic plan, but at a later date).

To help inform this process, we are inviting collaborations and scientists to submit short letters of interest (LOIs); maximum 3 pages. The information requested in the LOIs includes science goals, collaboration composition, facility requirements, access requirements, and timelines. Submitters are also invited to complete a SURF Experiment Planning Statement (EPS), supplemental to the LOI, that provides some additional experiment details as well as offering some SURF facility details: <https://sanfordlab.org/researchers/proposal-guidelines>.



SURF Experiment Implementation & Support

Framework for establishing relationships and expectations with experiments

Science Program Advisory Committee (SPAC)

<https://sanfordlab.org/science-program-advisory-committee>

- SPAC consists of up to **14 members** across scientific disciplines, incl senior + strong mid-career individuals, 3-year terms (extendable)

Purpose

- **Science Program:** Provide guidance on overall SURF scientific program (incl current/proposed expts); peer review per DOE User Facility (future)
- **Science Support:** Advise on SURF experiment implementation program and organizational capacity to support experiments
- **Science Facilities:** Advise on capability and capacity of the SURF facility necessary to support the SURF scientific program

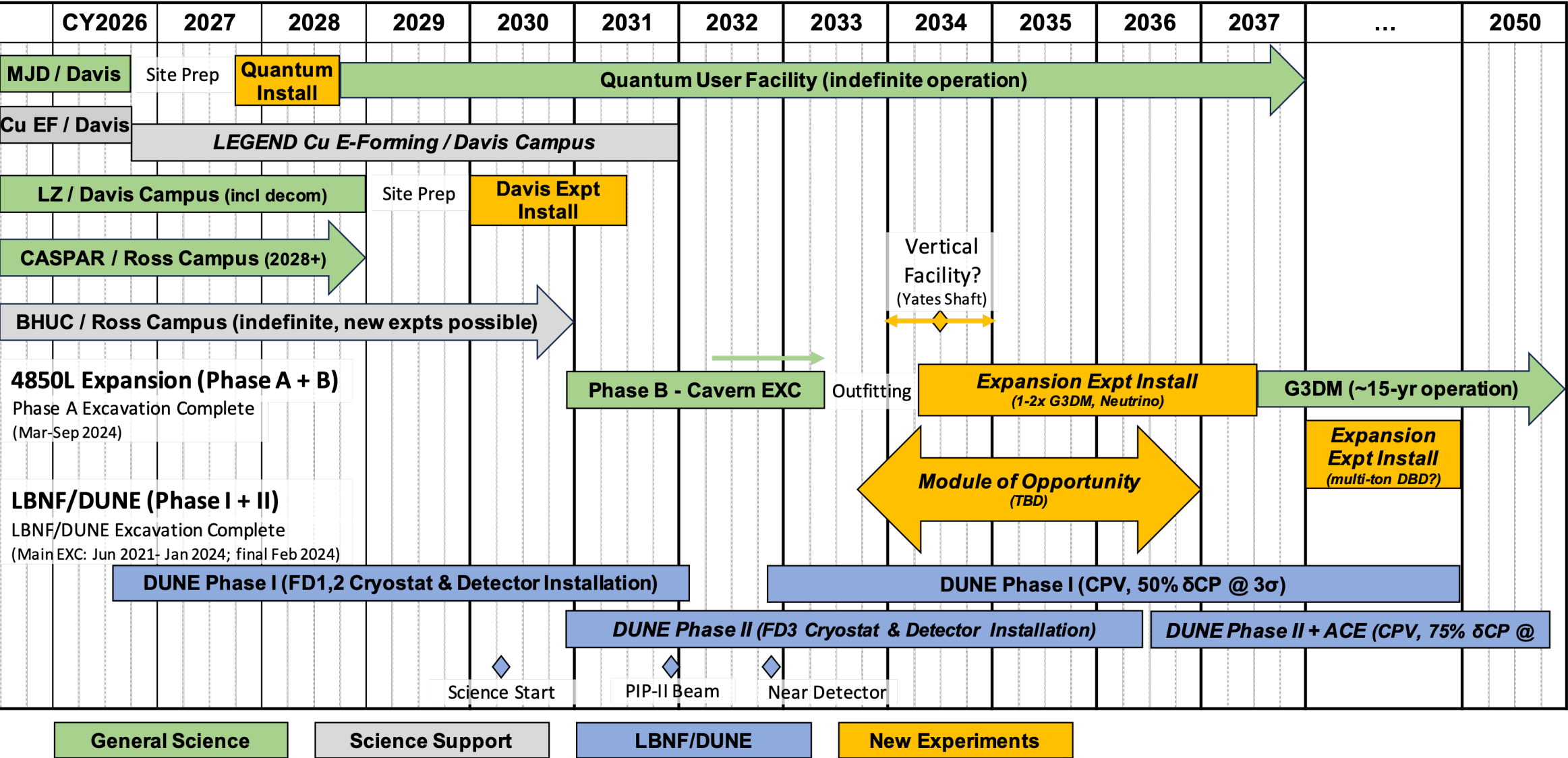
Experiment Review

- Expt proposal presentations, review of SURF 2024 Letters of Interest
- SPAC input on competing proposals for limited space at SURF using SDSTA-developed criteria:
 - Scientific merit and/or application impact; compatibility with SURF science program
 - Need for unique environment and characteristics offered at SURF
 - Technical, organizational, and funding readiness; environmental, safety, and operational risks



SURF Science Strategic Planning

Timeline

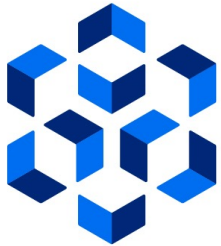


The Institute for Underground Science at SURF

Goal: The Institute for Underground Science at SURF constructed by Sep 2035

World-leading center for

- Underground science collaboration and intellectual community
- K-12 and public education & outreach programs



THE INSTITUTE
FOR UNDERGROUND SCIENCE
AT SURF



Institute for Underground Science at SURF

Advancing program vision using existing resources to build constituency

Vision

Create a dynamic intersection of KNOWLEDGE, PEOPLE, and PLACE, dedicated to building an unparalleled intellectual community and serving as a world-leading center for underground science and technology

Priorities



Build Intellectual Community



Foster Interdisciplinary Collaboration



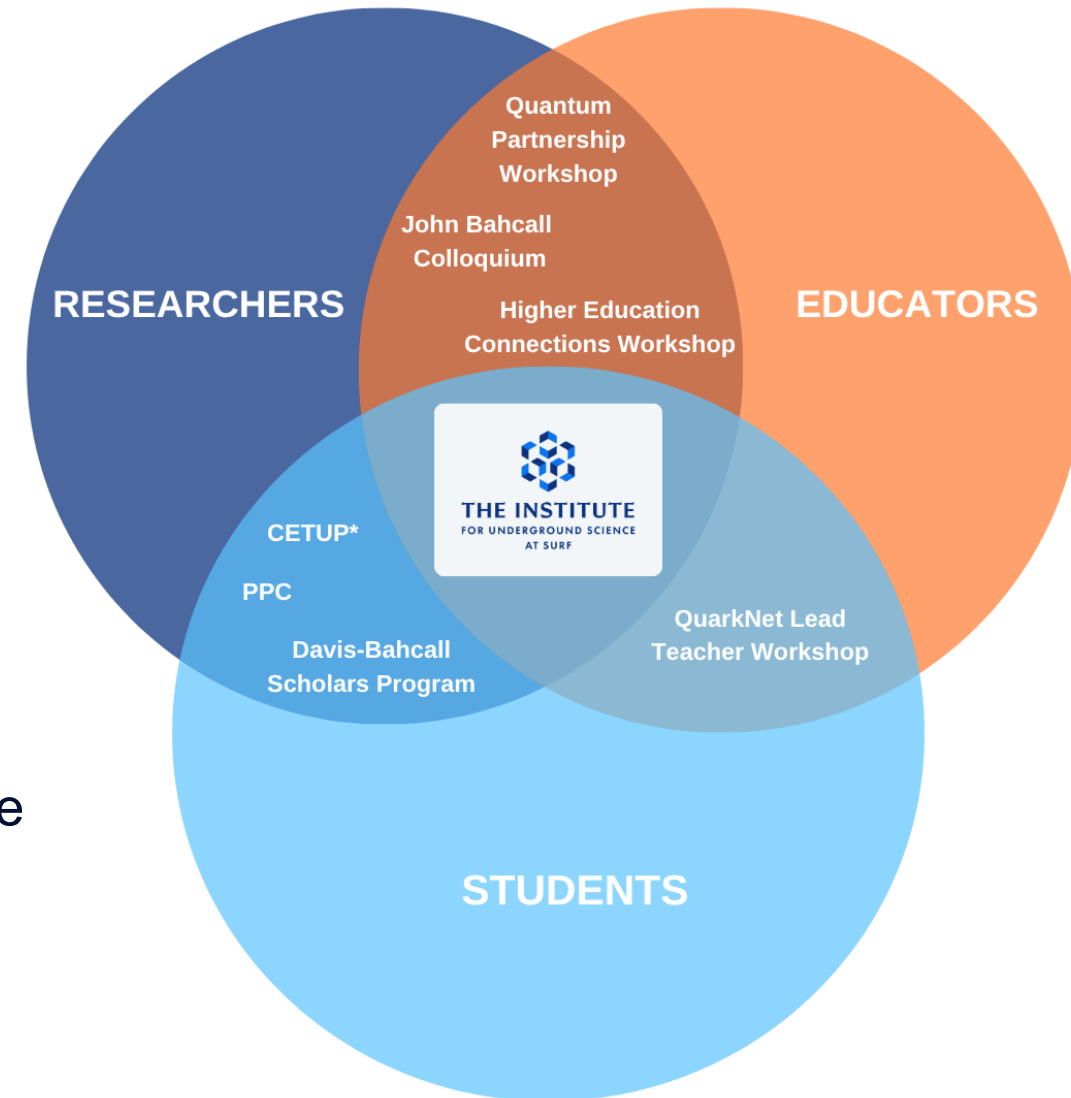
Construct a Path for Future Generations



Expand Educational Opportunities



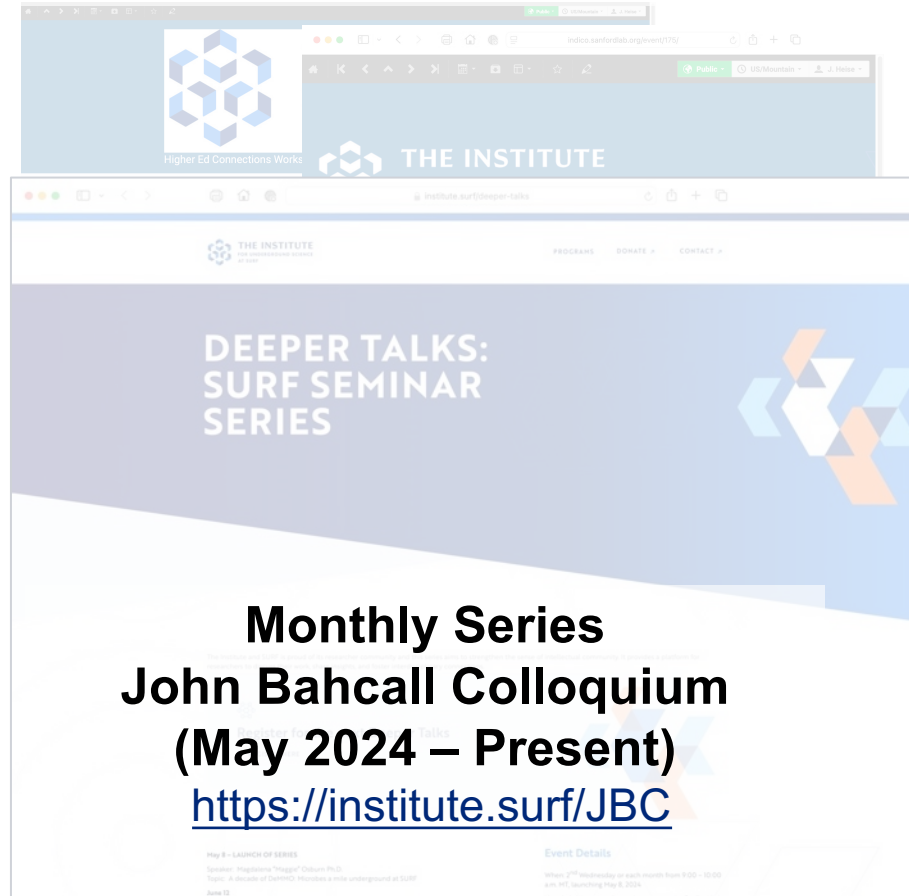
Establish Passionate Partnerships



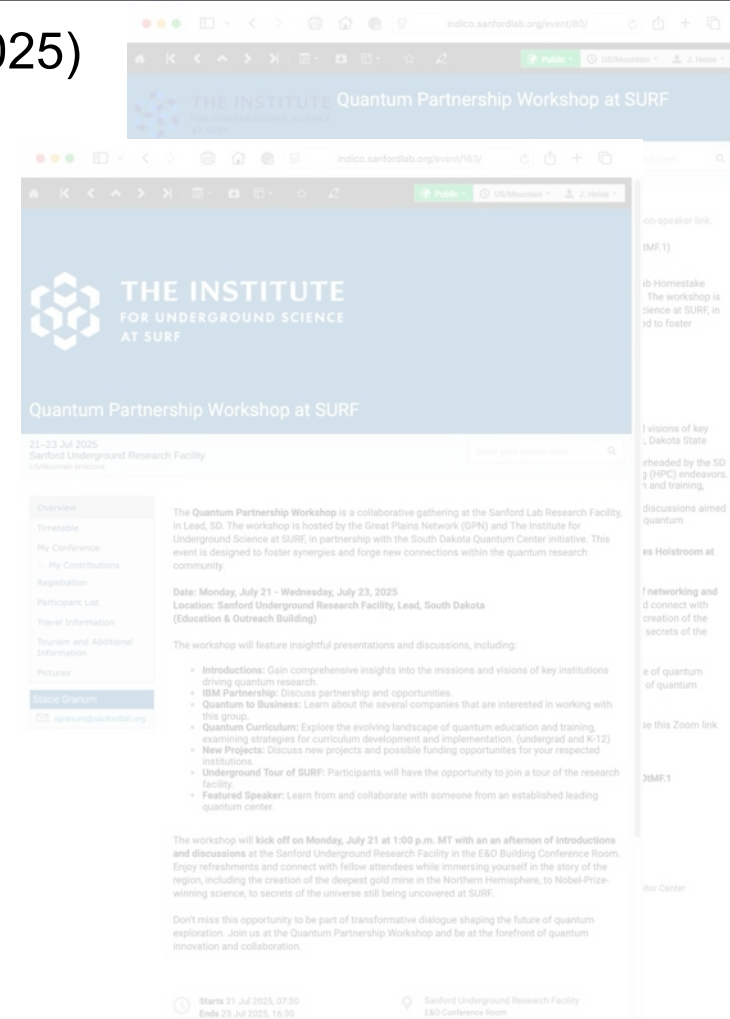
Institute for Underground Science at SURF

Activities since June 2023, formally launched December 2023

Higher Ed Connection Workshop (2024, 2025)
<https://indico.sanfordlab.org/event/76> / [175](https://indico.sanfordlab.org/event/175)



Monthly Series
John Bahcall Colloquium
(May 2024 – Present)
<https://institute.surf/JBC>



CETUP* (2023, 2024, 2025, 2026)
<https://indico.sanfordlab.org/e/CETUP2023> / [2024](https://indico.sanfordlab.org/e/CETUP2024) / [2025](https://indico.sanfordlab.org/e/CETUP2025) / [2026](https://indico.sanfordlab.org/e/CETUP2026)

Quantum Partnership Workshop (2024, 2025, 2026)
<https://indico.sanfordlab.org/e/QPW2024> / [2025](https://indico.sanfordlab.org/e/QPW2025) / [2026](https://indico.sanfordlab.org/e/QPW2026)



STEM Education at SURF



- SURF Education & Outreach team reaches **22,000+** K-12 students per year
 - Presentations and field trips
 - Curriculum units
- Professional development for more than **400** educators per year
- **Davis-Bahcall Scholars** program and **summer internship** opportunities (Apply this fall!)



K-12 Education & Outreach

Presentations and Field Trips	Curriculum Units and Resources	Career Exploration and Development	Supporting Teachers
• K12 presentations • Face-to-face • Virtual options • Field trips	• 17 unique curriculum units available for checkout • 5-15 hours of fully designed and resourced science curriculum	• Davis-Bahcall Scholars Program • Summer internship opportunities • Pre-service educator program support	• Professional development offerings • Curriculum resources • Science content support • Just-in-time support
			



Education & Outreach – By the Numbers

School Year	2019-2020 (covid begins)	2020-2021 (during covid)	2021-2022	2022-2023	2023-2024	2024-2025
Field Trips	254	58	485	972	966	1,501
Classroom Presentations	3,704	2,005	14,038	12,799	10,281	14,712
Curriculum Units	3,236	3,384	3,718	2,554	3,965	4,171
Other	918	298	1,468	1,596	1,368	1,729
Total Student Contacts	8,112	5,745	19,709	17,921	16,580	22,113

August 2024 – July 2025: Developed and facilitated more than 6000 people hours of professional development for more than 400 educators



Sanford Lab Homestake Visitor Center

Acquired January 2022. Greatly expands public outreach opportunities.



Sanford Lab Homestake Visitor Center (SLHVC)

Building meaningful relationships with range of audiences

Audiences

- Intergenerational year-round programming
- Venue space for SURF and its affiliates
- Local community
- Tourists

Engaging Content

- Docent tours
- Ask-a-Scientist events
- *Deep Talks* lecture series
- *Deep Roots* cultural events
- Tours to hoist room and Čanglěška Wakhánj

Accessible Opportunities

- Accessibility strategic plan in process
- Serves as SURF's public "front door"
- Multi-use space
- Community partner:
 - Voter polling site
 - Visitor center for tourists
 - Exploring public EV charging station



By the Numbers

	2023	2024	2025
Visitors	57,317	58,136	55,484
States	50	50	50
Countries	33	42	41
Buses	139	137	158
Events	121	124	140



Čanġlěška Wakħán, the Ethnobotanical Garden at SURF

Public tours started summer 2024



Sanford Underground Research Facility

General summary

Site: Deepest underground lab in U.S., largest footprint for scientific pursuits (former Homestake Gold Mine). Operations funded directly by U.S. Department of Energy (\$44M/yr). Robust org, total staff = 225 ppl.

Science Program:

- **Past:** Davis Solar Neutrino Experiment, LUX, MAJORANA DEMONSTRATOR ($0\nu\beta\beta$, $^{180\text{m}}\text{Ta}$), others (incl Deep Underground Gravity Lab, affiliated w/ LIGO collaboration; Industry/engineering w/ Caterpillar)
- **Current:** LZ, CASPAR, Low-bkgd counting (BHUC), Geoengineering (esp. geothermal, seismic), Geomicrobiology, Engineering
- **Future** (no funding/site decisions yet):
 - Dark Matter: Low-mass (SPLENDOR, HydroX), next-generation WIMP (XLZD, Argo), other (CrystaLiZe)
 - Neutrino: Liquid scintillator (Theia), multi-ton-scale $0\nu\beta\beta$ (LEGEND 6000), XLZD, etc
 - QIS, atom interferometry – gravitational waves, ultra-light dark matter: km-scale vertical or horizontal

Facility:

- **4850L Existing:** Davis Campus and Ross Campus operating well
- **4850L Quantum User Facility:** Dilution fridge for QIS at Davis Campus (exploring funding avenues)
- **4850L LBNF/DUNE:** Excavation complete, “Module of Opportunity” for expanded science program (DOE)
- **4850L Expansion:** Up to 2x caverns (100m L × 20m W × 24m H), complete in early 2030s (private/DOE?)
- **Vertical Facility:** Accommodate during Yates Shaft refurbishment, schedule TBD / ~2030s (DOE/other?)



Sanford Underground Research Facility

Physical characteristics

- **Property:** 1 km² (surface) with ~1600 m² storage (incl drill core) and 355 m² staging/assembly space; 31 km² (total underground) with ~600 km of tunnels extending to over 2450 m below ground.
- **Access:** Vertical; personnel and materials via one of two main shafts (Yates Shaft extensive maintenance campaign completed, DOE funding discussions for full refurbishment). Facility dedicated to science.
 - Yates Shaft: 1.39 × 3.77 × 2.58 m, 4.8 tonnes (lengths up to 7.3 m possible at reduced payload mass)
 - Ross Shaft: 1.40 × 3.70 × 3.62 m, 6.1 tonnes (lengths up to 8.2 m possible at reduced payload mass; new cage soon)
- **Depth:** Main UG level = 4850L (1480 m, 4300 mwe), muon flux = $(5.18 \pm 0.27) \times 10^{-5} \mu/\text{m}^2/\text{s}$ (4.5 $\mu/\text{m}^2/\text{d}$). Several other UG elevations for science: 300L, 800L, 1700L, 2000L, 4100L, 4550L.
- **Space:**
 - Surface (science space, as low as class 10-100): 210 m² (cleanrooms = 92 m² / 914 m³)
 - 4850L (science space, as low as class 100): Davis Campus (1018 m² / 4633 m³), Ross Campus (920 m² / 3144 m³)
 - Radon-reduction: Surface = 2200x reduction @ 300 m³/h (Ateko), Davis = 700x reduction @ 150 m³/h (SD Mines)
- **Bkgds** (4850L): Radon* = 210-330 Bq/m³, gamma = 1.9 $\gamma/\text{cm}^2/\text{s}$, neutron (thermal) = $1.7 \times 10^{-2} \text{ n}/\text{m}^2/\text{s}$.
- **Utilities:**
 - Power = 24,000 kW capacity (20,000 kW available now, 15,000 kW in FY27); Standby = 3 diesel generators (390 kW)
 - Chilled water (2x 246 kW), purified water (37.8 lpm), compressed air (up to 1100 scfm, 140 scfm at Davis Campus)
 - Network = 20 Gbps internally, 10 Gbps externally (100 Gbps planned), WiFi available surface + underground

* Studies conducted Summer 2024, expect to reduce Rn concentration



Sanford Underground Research Facility

Capabilities

- **Unique environments for multi-disciplinary research:** SURF has attracted world-leading experiments and scientists from diverse scientific communities.
 - **Overburden protection from cosmic-ray muons:** SURF is the deepest underground lab in U.S., one of deepest laboratories in the world (1500 m, 4300 mwe). SURF is expanding to meet the needs of next-generation experiments
- **Local radiation shielding:** Water tank and corresponding water purification system, steel shielding; also selection of low-activity facility construction materials/finishes (e.g., concrete, shotcrete)
- **Assay capabilities:** Low-bkgd counting serving national & international community ($\sim 10 \mu\text{Bq/kg}$ U/Th)
- **Material production/purification:** One of only a few labs where UG Cu electroforming is performed (average U, Th decay chain $\leq 0.1 \mu\text{Bq/kg}$)
- **Environmental control:** Experience w/ HEPA filtration cleanrooms, dehumidifier, Rn-reduction systems
- **Implementation and operations support:** Robust organization with support for planning, execution and coordination of science program activities both planned and ongoing at facility. SURF has proven track record of delivering successful science.
- **Community catalyst:** User Association, incl Vision Workshop 2021. Science Program Advisory Cmttee. Both groups support upcoming SURF application to become **DOE Office of Science User Facility**

